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case studies

a current report on solid waste management

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COST OF LANDSPREADING AND HAULING SLUDGE FROM MUNICIPAL WASTEWATER TREATMENT PLANTS

Case Studies

This report (SW-619) was written
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FOREWORD

It has been estimated that about 25 percent of the municipal wastewater treatment plant sludge produced in the United States is disposed of by landspreading. Landspreading is the practice of applying sludges to the land so as to utilize certain inherent characteristics of the material for agricultural benefits. While landspreading of sludges is a common practice, the cost of this operation is seldom known. The primary reasons for this being poor record keeping, or not being able to break down the total operating cost for the sewage treatment plant by function. Therefore this study was designed to determine the cost of existing landspreading operations rather than to evaluate the potential environmental benefits or hazards of landspreading.

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COST OF LANDSPREADING AND HAULING SLUDGE FROM MUNICIPAL WASTEWATER TREATMENT PLANTS

by R. Kent Anderson*

I. INTRODUCTION AND SUMMARY

A. Purpose

This report presents an analysis of the cost of disposing of municipal wastewater treatment sludge on land by existing operations. It is based on an on-site survey of 24 communities with small to medium-sized plants, i.e.. all with throughputs of less than 100 million gallons per day (MGD). The analysis differs from other studies in that much of the available literature has been developed for large communities with sizable quantities of sludge. For these communities, landspreading costs are considerably higher than for smaller communities due to longer haul distance, increased capital requirements, and higher labor rates. The 24 city survey was thus designed to provide reliable cost information for small communities interested in landspreading wastewater treatment sludge on land. However, it should be noted that the cost of new operations may be somewhat higher due to increased cost of equipment.

B. Scope of Study

The communities selected for the study were chosen on the basis of (1) treatment plant size, and (2) sludge dewatering processes employed. This was done to obtain as wide a range of landspreading practices and costs as possible.

Three different plant sizes were selected:

Average Daily Flow (MGD)	Number of Communities
< 5	7
5-10	4
> 10	13

For purposes of this study, plants processing over 10 MGD are referred to as large plants, 5-10 MGD as medium-sized plants, and less than 5 MGD as small plants. Table 1 presents a list of the communities chosen with their average daily flow.

Using the average daily flow in MGD as the major means of categorizing the communities, an effort was also made to obtain a balanced selection of liquid and dewatered haul systems for each size category.

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* Mr. Anderson is a sanitary engineer with the Special Wastes Branch, Office of Solid Waste, U. S. Environmental Protection Agency, Washington, D. C.

TABLE 1

TREATMENT PLANTS SELECTED

LARGE TREATMENT PLANTS	AVERAGE FLOW (MGD)
Toledo, Ohio	92
Louisville, Kentucky	90
Grand Rapids, Michigan	47
Salt Lake City, Utah	41
Salem, Oregon	28
Springfield, Ohio	20
Anderson, Indiana	18
York, Pennsylvania	16
LaCrosse, Wisconsin	14
Macon, Georgia	13
Appleton, Wisconsin	12
Bethlehem, Pennsylvania	12
Danville, Virginia	10.5
MEDIUM TREATMENT PLANTS	
Sheboygan, Wisconsin	10
Greeley, Colorado	6.5
Belleville, Illinois	5.5
Littleton, Colorado	5
SMALL TREATMENT PLANTS	
Lebanon, Pennsylvania	4
Fort Pierce, Florida	3.5
Rochelle, Illinois	3.2
Greene County, Ohio	2.6
Collinsville, Illinois	1.2
Front Royal, Virginia	1.2
Lawrenceville, Illinois	.5

Nearly half of the communities selected used two systems to handle their sludge. Reasons for this include the fact that many communities had insufficient handling capacity in their primary system, and that seasonal restrictions in conjunction with limited storage capacity prevented the use of only a liquid system. The following breakdown was therefore obtained for the 24 sites:

Type of Sludge	Plant Size		
	Small	Medium	Large
Liquid	5	3	8
Dewatered			
Vacuum Filter	2	1	8
Sand Drying Beds	0	3	2
Centrifuge	0	0	1
Lagoon	0	0	1

To determine the cost of landspreading, data was collected on sludge quantities and detailed cost breakdowns during an on-site visit to each of the communities. However, certain assumptions were made to make the data comparable. All equipment was depreciated at 8 percent interest. The depreciation period used for vehicles was 8 years, stationary equipment was 10 years, while buildings were depreciated over 20 years. In addition, a 10 percent contingency factor was added to the cost of each system to cover such items as administrative overhead.

C. Findings

1. The landspreading of liquid sludge was found to be far less expensive than landspreading sludge dewatered by vacuum filtration.

Analysis of the data developed during the course of this study indicates that landspreading liquid sludge is far less expensive than landspreading sludge dewatered by vacuum filtration. Indeed, the average cost of the dewatering process alone ($61/dry ton) was found to be considerably more expensive than the entire haul and landspreading cost for liquid sludge. Those communities that disposed of liquid sludge had an average cost of $32 per dry ton, while those that dewatered their sludge averaged $87 per dry ton. Even for those communities that disposed of both liquid and dewatered sludge, the vacuum filtered sludge operation was two and a half times more expensive than the liquid haul operation. Since most communities spread the liquid sludge on the land but only dump the dewatered sludge in piles for the landowner to spread at his own expense, the dewatered sludge operation would be even more expensive under comparable conditions.

2. Personnel costs represented the largest single cost item for both liquid and dewatered sludge landspreading.

Of the $32 per dry ton cost for liquid sludge disposal, approximately $13, or 42 percent of the total, was expended for personnel. As would be expected, the round trip haul time involved in transporting the sludge is the major personnel cost item.

For the combined operation of dewatering and hauling vacuum filtered sludge, the average cost per dry ton was $87. As with liquid haul, personnel is the largest cost item in the vacuum filtered sludge disposal operation. It accounts for 22 percent of the total, followed by chemicals at 20 percent and utilities at 16 percent. With vacuum filtered sludge, the dewatering operation had an average cost per dry ton of $61. Personnel, again, was the largest cost item at 36 percent of the total, followed by chemicals at 24 percent and maintenance on the vacuum filters at 17 percent.

3. Liquid sludge was more readily acceptable to the farming community than dewatered sludge.

While none of the municipalities surveyed encountered great resistance to their sludge landspreading practices, liquid sludge was sought with much more frequency and enthusiasm than dewatered sludge. This preference on the part of the farmer is due both to the cost differential (the municipality always spreads the liquid sludge on the fields, but not necessarily the dewatered), and to the fact that dewatered sludge is more difficult to handle and apply evenly.

II. CURRENT SLUDGE HANDLING PRACTICES

The desirability and feasibility of sludge landspreading is dependent upon many factors. Although cost is a consideration in the selection of a sludge utilization or disposal alternative, it does not appear to always be the prime factor. Many communities find that disposal site availability, transportation modes and application methods suitable for either liquid or dewatered sludge landspreading, are more critical than cost in selecting the system or systems to be used in disposing of their sludge. A brief discussion of the transportation and landspreading systems employed by the 24 communities follows.

A. Transportation Systems

1. Liquid Sludge

Liquid sludge is most commonly hauled by truck, although pipelines, barges, and rail tank cars are also possible modes of transportation. Of the 16 communities surveyed that hauled liquid sludge, all used trucks as their sole conveyance mode.

Truck capacity varied widely among the communities surveyed; the smallest capacity was 1,400 gallons, while the largest was a 6,000 gallon tractor trailer. Two of the 16 communities used tractor trailers. Although these were not large communities, they generated liquid sludges with extremely low percentages of solids which account for their need for trucks with larger capacities. The average, as well as the median, truck capacity for the liquid haul systems was 2,500 gallons.

The communities surveyed used from one to six trucks per plant. Although two of the plants that handled larger quantities of liquid sludge utilized the largest truck fleets, one of the smallest plants had two trucks which were only utilized 7 percent of the time. Because the capital cost for trucks amounts to 16 percent of the total cost of disposing of liquid sludge, a reduction in excess truck capacity could result in a cost savings. However, at some plants, excess truck capacity was necessary since the sludge generated in the course of an entire year was hauled during the few months that disposal sites were available for use. In these communities sludge was usually stored in oversized digesters or inoperable digesters.

The typical community surveyed used one or two truck drivers. The number of drivers employed was closely tied to the number of trucks, and not necessarily to plant size. Table 2 shows the number of trucks and drivers per community along with averages and medians.

Haul distance ranged from one half mile to 30 miles round trip, with an average round trip distance of 12 miles. Many of the communities surveyed used haul distance as a criterion for disposal site selection, and would not normally haul outside of a five or ten mile radius of the treatment plant. The time required to drive to and from the utilization sites varied from five minutes to 60 minutes with a median round trip time of 25 minutes.

2. Dewatered Sludge

For the 16 cities that spread dewatered sludge on the land, the transportation system usually consisted of one to three dump trucks operated on a part-time basis. Capacity of the trucks ranged from 2 1/2 cubic yards to 30 cubic yard tractor trailers. At three of the cities, the sludge hauling operation was contracted to a private hauler who used larger capacity trucks and transported the sludge a greater distance. For the city operated systems, the average truck capacity was 8 cubic yards. The number of trucks and their size usually increased with increased sludge production, except where the sludge was spread on plant property. As would be expected, the transportation costs were minimal (usually less than one dollar per dry

Table 2

Truck Drivers and Trucks Utilized in the Liquid Haul Operations

City	Number of Truck Drivers	Yearly Percent Each Worked	Number of Trucks	Yearly Percent Each Used
Anderson, Ind.	5	46	6	38
Belleville, Ill.	2	18	2	18
Bethlehem, Pa.	1	15	1	15
Collinsville, Ill.	2	10; 40	1	50
Danville, Va.	2	60	2	60
Ft. Pierce, Fla.	2	40; 90	2	65
Front Royal, Va.	1	5	1	5
Greeley, Colo.	1	90	1	90
Greene Co., Ohio	1	38	2	19
LaCrosse, Wisc.	2	100	1	200*
Lebanon, Pa.	1	14	2	7
Macon, Ga.	1	14	1	14
Salem, Ore.	1	80	1	80
Springfield, Ohio	1	19	2	10
York, Pa.	4	100	5	80
Average	1.8	53	2	48
Median	1	46	2	38

*A two-shift operation.

ton) if the sludge was disposed of on plant property, i.e., within a very short haul distance. One city utilized two truck drivers full time, while the remainder only used one driver. Table 3 shows the number of trucks and drivers per community along with averages and medians.

The haul distances for dewatered sludge ranged from one quarter mile to 90 miles round trip, with an average round trip distance of 16 miles and a median distance of 10 miles. This required an average round trip driving time of 37 minutes. In comparing the average driving time of 28 minutes for the liquid systems and 37 minutes for the dewatered systems, it appears that the cities included in the survey took longer to transport their dewatered sludge than their liquid sludge. However, Toledo, Ohio hauls their dewatered sludge a far greater distance and has a longer driving time than any other city surveyed. If Toledo's system is excluded from the dewatered sludge analysis, the average round trip driving time is 29 minutes. This indicates that the driving times for both liquid and dewatered sludge hauling are nearly identical. Therefore, from the communities surveyed, distance or haul time to disposal sites was not a reason for or justification to dewater the communities' sludge. However, dewatering does result in far less material for transportation.

B. Landspreading Systems

1. Liquid Sludge

All the communities surveyed spread liquid sludge directly from the truck. * The breakdown of liquid spreading mechanisms is as follows: one injected the sludge into the soil with a subsod injector on the rear of the truck; three used a pressurized spray nozzle; three used rear mounted splash plates; five used a rear mounted "T" pipe; and four did not use any distribution device.

In order to insure a uniform application of liquid sludge, the application rate must be geared to the ground speed of the truck and independent of the hydraulic head created by the sludge remaining in the tank. Otherwise, when the truck is driven down hill, or near the end of the load the application rate will decrease markedly. If no distribution device was utilized, the application tended to be rather uneven. In these cases, the sludge flows directly from a valve at the rear of the truck, and covers a 2 to 3 foot wide swath

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* After the site visits were made, Greene County, Ohio, began utilizing a sprinkler irrigation system. The irrigation system consists of a farm tractor driven centrifugal pump, 1,500 feet of irrigation pipe with a single riser and nozzle. Using this system, their 6,000 gallon tractor trailer can be unloaded from the roadway in 20 minutes.

Table 3

Truck Drivers and Trucks Utilized in the Dewatered Haul Operations

City	Number of Truck Drivers	Yearly Percent Each Worked	Number of Trucks	Yearly Percent Each Used*
Anderson, Ind.	1	30	2	15
Belleville, Ill.	1	5	1	5
Bethlehem, Pa.	1	30	1	30
LaCrosse, Wisc.	2	100	2	100
Lawrenceville, Ill.	1	0.5	1	0.5
Louisville, Ky.	1	100	3	33
Rochelle, Ill.	1	75	3	25
Salt Lake City, Utah	1	12	1	12
Springfield, Ohio	1	34	2	17
York, Pa.	1	100	2	50
Average	1.1	48.6	1.8	28.8
Median	1	32	2	21

*In addition, some trucks are used an additional amount of time in a storage capacity while a load of sludge is being dewatered.

as the truck is driven across the field. In order to completely cover the field, the truck must be driven on previously applied sludge which results in both poor traction and tracking of sludge onto roadways. Figure 1 shows an extreme case of applying sludge without a distribution system. In this example, the fields were too wet to traverse with a truck so sludge was applied with a hose emanating from a tractor trailer parked on the roadway. Since this picture was taken, the system has been abandoned in favor of a sprinkler irrigation system because of the uncontrollable and spotty application rate received with the previous system.

A splash plate or perforated "T" pipe will eliminate some of the distribution problem by applying sludge over an area at least as wide as the width of the truck. However, even with a distribution system of this sort, a much heavier application will be made at the start as compared to the end of unloading unless the speed that the truck advances across the field is steadily decreased to compensate for the steadily decreasing hydraulic head. Figures 2, 3, and 4 illustrate various types of "T" pipes. Figure 5 provides an example of a "T" pipe with a splash deflector device for more even distribution.

The pressurized injection or distribution systems will eliminate these problems of tracking sludge onto roadways and of uneven application. By pressure spraying sludge from the side or rear of the truck, a wide enough area can be covered to eliminate the need of having to drive on previously applied land. Also the application rate is not dependent upon the quantity remaining in the tank or whether the truck is being driven up or down hill. The injection system has additional advantages in that a follow-up operation to incorporate the sludge into the soil is not needed. Many states require or recommend that surface applied sludge be disced or plowed under. Also, this system virtually eliminates the chance of odors, greatly reduces the chance of sludge loss due to erosion or loss of nutrients to the atmosphere. The injection system has the disadvantage of greater power requirements for unloading while any pressurized discharge system could have the potential disadvantage of pump maintainance. Figures 6 and 7 illustrate two types of pressure systems. Figure 6 is a side discharge, pressure spray system. Figure 7 is a rear mounted pressure system with splash plate.

Although there is a wide variation in the effectiveness of the various distribution devices employed, there appears to be little correlation between the acceptability of the sludge to the farmer and the effectiveness of the distribution system. In general, liquid sludge landspreading systems were considered desirable by the farming community, regardless of the transportation system or application method employed.

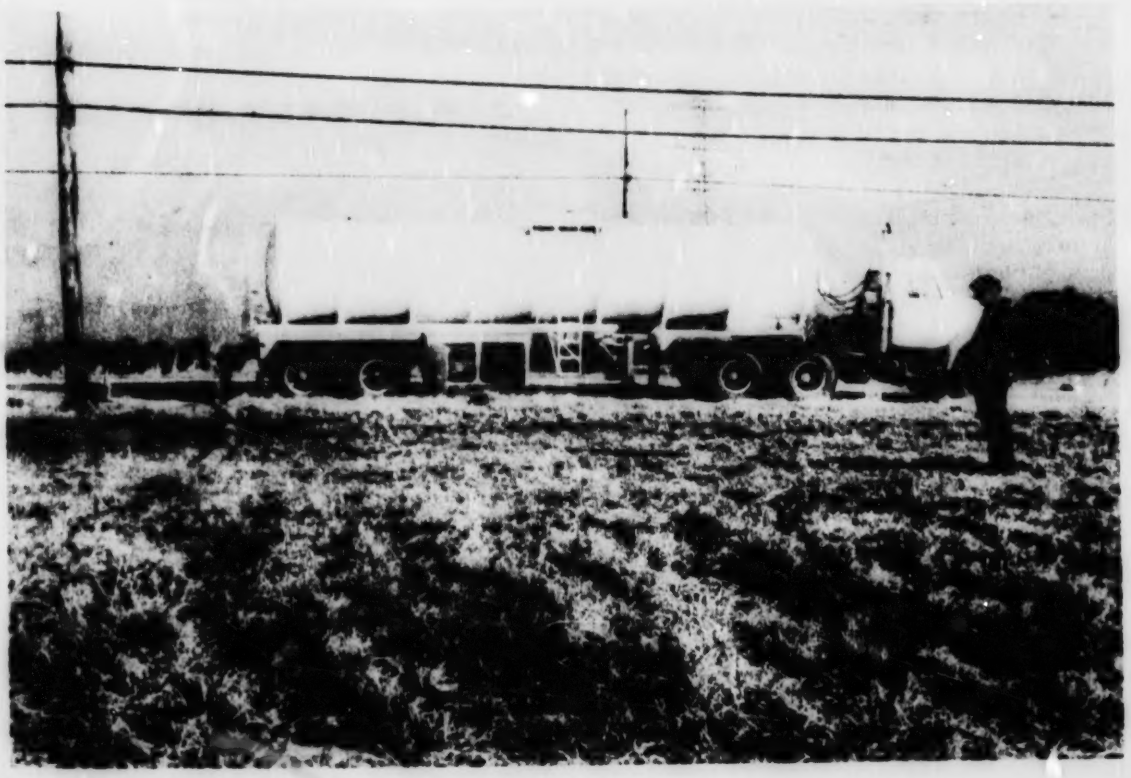

Figure 1--Tractor Trailer with Hose in Greene County, Ohio

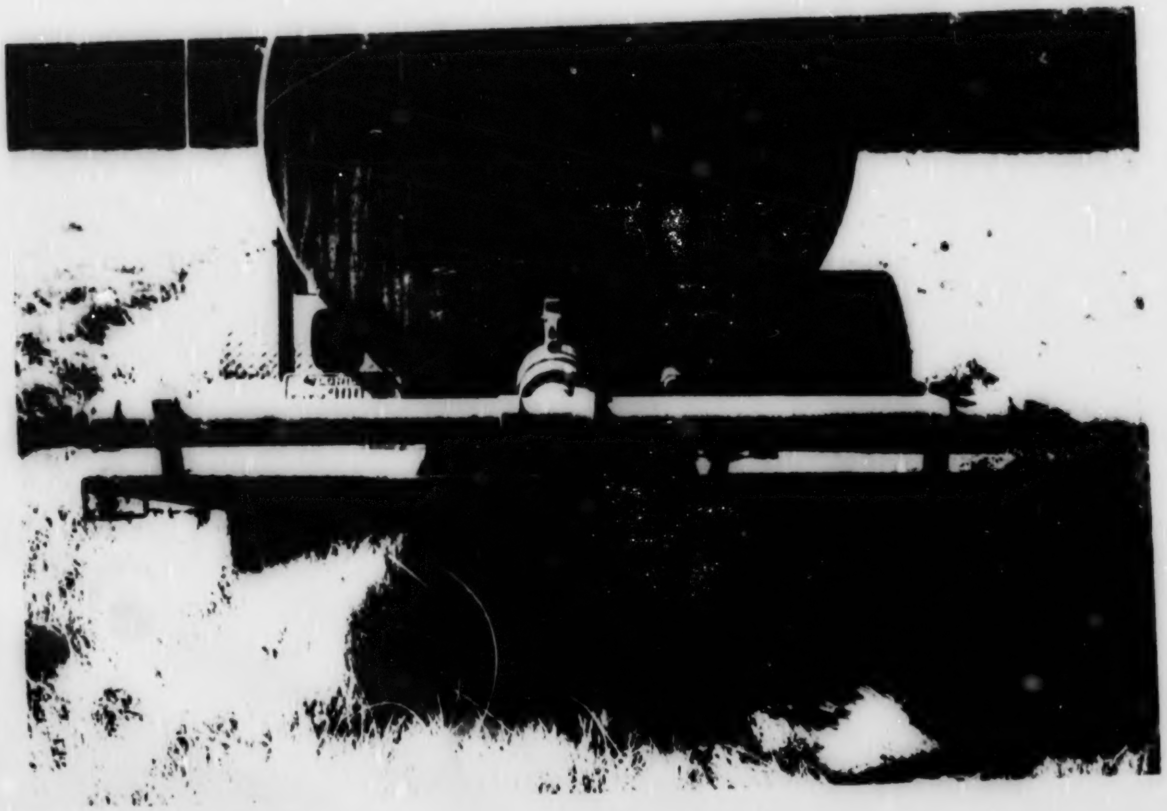

Figure 2--Open End "T" Pipe in Ft. Pierce, Florida

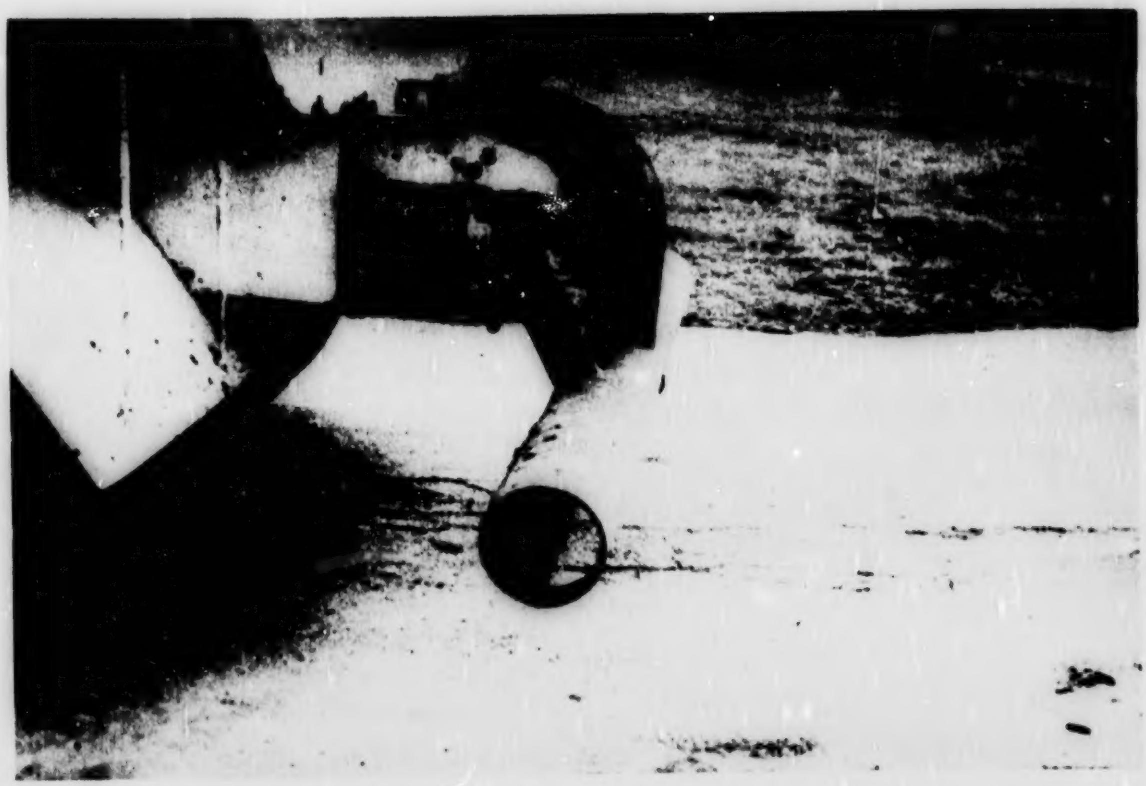

Figure 3--Slotted "T" Pipe in Springfield, Ohio

Figure 4--Perforated "T" Pipe in Front Royal, Virginia

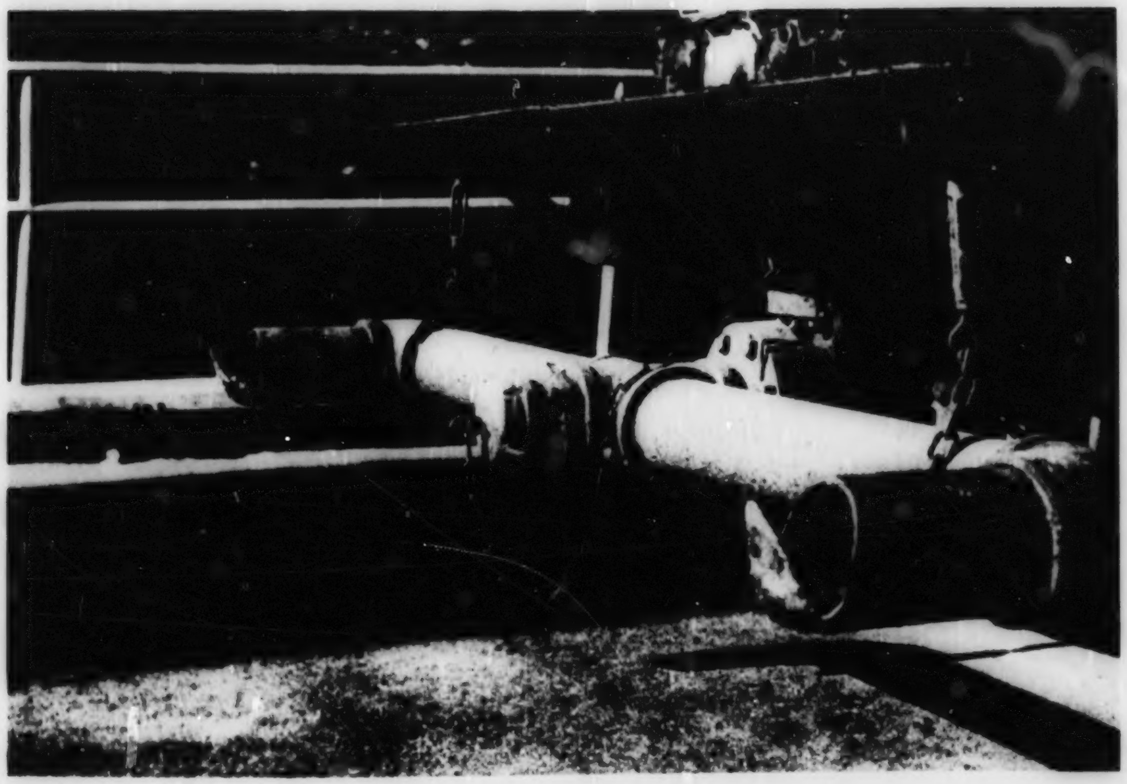

Figure 5--"T" Pipe with Splash Deflector Device in Bethlehem, Pennsylvania

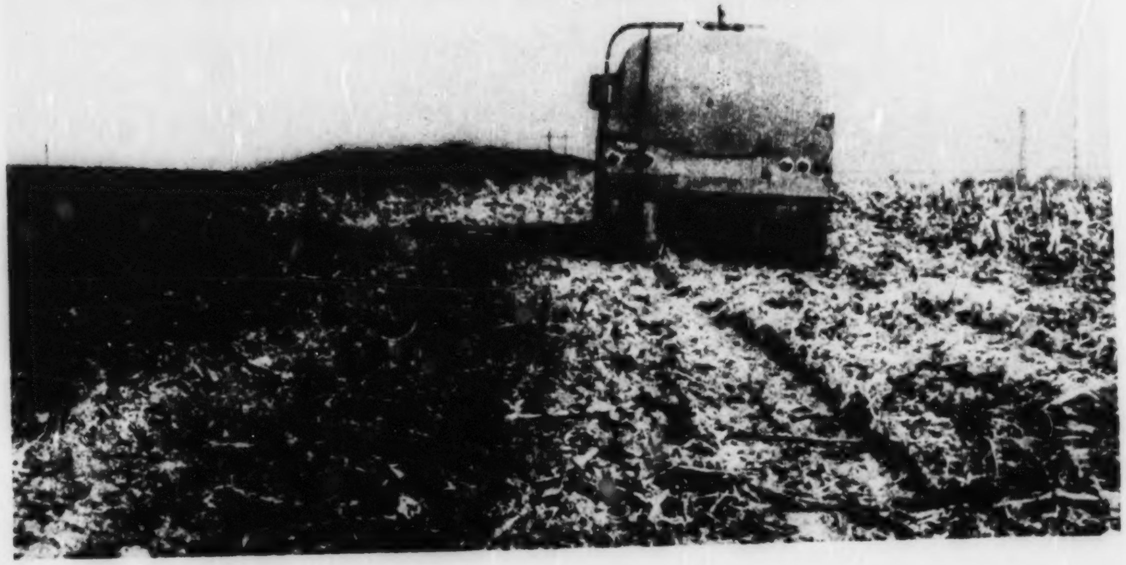

Figure 6--Side Discharge, Pressure Spray System in York, Pennsylvania

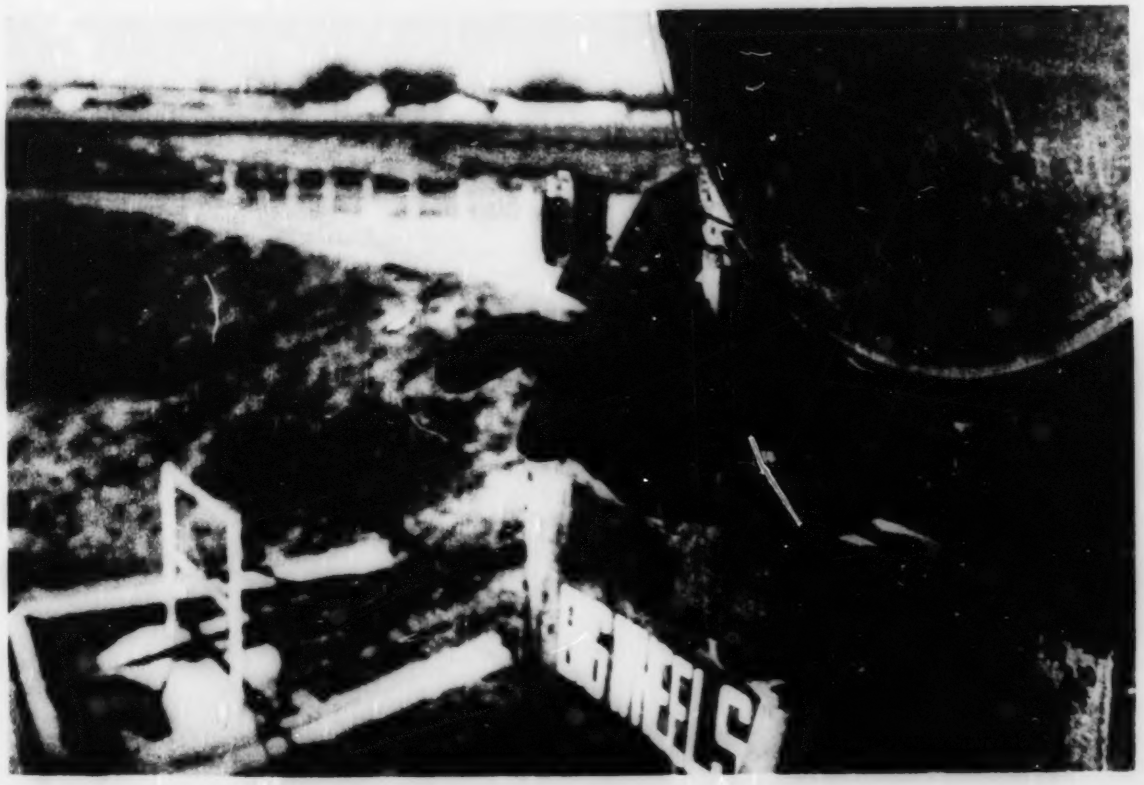

Figure 7--Big Wheel Pressure System with Splash Plate in Collinsville, Illinois

2. Dewatered Sludge

Most of the communities surveyed hauled dewatered sludge to the farm site and then dumped the sludge in piles. The landowner was responsible for spreading and incorporating the sludge into the soil. One exception to this was in Appleton, Wisconsin. Here, the City contracted with a firm to haul the sludge to farmland. When the driver arrived at the site, he dumped the load of sludge adjacent to the previously applied area and used a tracked dozer at the site to spread his load. At the end of the day, a four wheel drive farm tractor is used to plow the area which had received sludge that day. In most cases, there was no charge to the farmer for this service. Figure 8 illustrates sludge after spreading but prior to incorporation into the soil.

Many of the cities that dewatered sludge stockpiled at least a portion of their sludge on the treatment property for local citizens to obtain. The major advantage of this system is that the city does not need to locate receiving areas nor bear the expense of hauling the sludge long distances.

In some cases, the municipality found it more difficult to dispose of its dewatered sludge than its liquid sludge. In York, Pennsylvania, for example, the municipality is hauling liquid sludge to 40 farms. But it has only been able to locate two farms that will accept its dewatered sludge, primarily because the farmer would have to spread the sludge and incorporate it into the land himself. In another community, Bethlehem, Pennsylvania, the dewatered sludge is typically landfilled because of a lack of interest on the part of the farming community.

III. ECONOMICS

A majority of the communities visited did not maintain detailed records on either the quantities of sludge handled, or the various cost factors involved in the disposal operation. As a result, some of the quantitative data utilized in this analysis are estimated values derived from interviews with treatment plant personnel and city hall offices. The data are nevertheless considered to be reliable and well within the range of sludge landspreading costs of existing systems. However, the communities studied in the survey are not necessarily representative of all communities using the various disposal methods. The cost of new operations may be higher than those found in this survey due to increased costs of capital items. In some cases, however, the reported cost may be too high because a 10 percent contingency factor was added to the total cost of each system. This contingency factor was added to cover miscellaneous costs such as administrative overhead. For purposes of this survey, sludge disposal costs include all post stabilization processes.

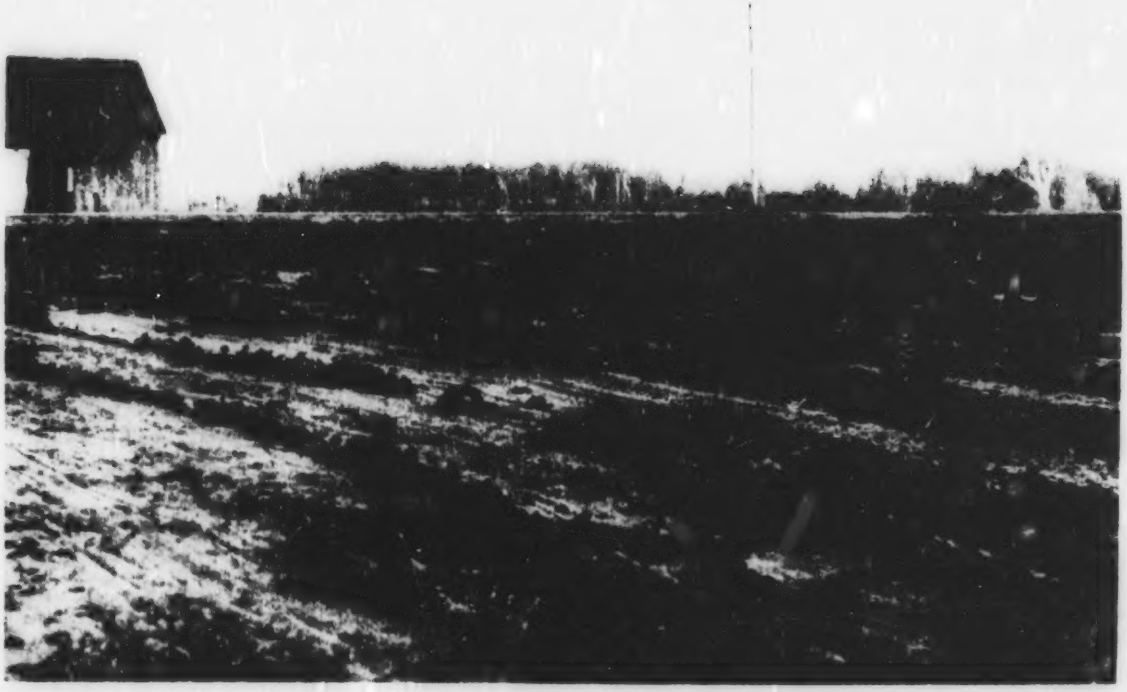

Figure 8--Spread Vacuum Filtered Sludge in Appleton, Wisconsin

In analyzing the cost data, Sheboygan, Wisconsin, had unusually high costs for the handling of both their liquid and vacuum filtered sludges. Sheboygan's liquid haul operation was the only contracted liquid disposal system surveyed, and was over 50 percent higher than the next most costly operation. It was impossible to determine the cost for disposal of Sheboygan's dewatered sludge since the City's incineration costs were not available. Also, the City's dewatering costs were nearly three times higher than the next most costly dewatering operation. The high dewatering costs are mainly attributed to high depreciation charges, expensive chemical requirements and high personnel costs. Because these costs are so much higher than those obtained from any of the other cities visited, they are not considered representative and have, therefore, not been included in the analysis.

Of the communities surveyed, 16 disposed of all or part of their sludge as a liquid at an average cost per dry ton of $32. In comparison, 11 communities disposed of part or all of their sludge after dewatering by vacuum filtration for a total cost of $87 per dry ton. Five communities used sand drying beds to dewater their sludge prior to disposal for a total average per dry ton cost of $14. In addition one city each used lagooning and centrifuging to dewater their sludge prior to disposal at a total cost of $9 per dry ton and $20 per dry ton respectively. At the plants which dewatered their sludge by sand drying beds, lagoons and centrifuges, the reported costs are most likely lower than would be the case for another community initiating these practices. With all three of the systems, the cost of trucking the dewatered sludge was very low or nonexistent since the dried sludge was usually used on site or stockpiled for citizen use. Also the drying beds and lagoons were older installations that did not have any depreciation charges. Many communities also used secondhand trucks for transporting sludge which resulted in lower depreciation costs. Tables 4 and 5 present summaries of the cost data.

1. Liquid Sludge

At the plants that disposed of part or all of their sludge as a liquid, the cost of disposal for the average dry ton of sludge was $32. However, this varied from a low of $5 per dry ton to a high of $81 per dry ton (Sheboygan's cost is $125 per dry ton). When comparing the size of operation to the cost per dry ton, the data points are widely scattered and there is no apparent relationship between annual quantity of sludge hauled and its associated cost per dry ton. However, when comparing cost per dry ton to round trip haul time (Figure 9), there appears to be a very strong relationship.

In this case, a line (linear mode) was fitted to the data using regression analysis. One standard deviation was used to

Table 4

Liquid Sludge Landspreading Cost Summary

Community	Liquid Sludge Produced (Dry tons/year)	Total Cost ($/dry ton)
Anderson, Indiana	2,960	19
Belleville, Illinois	500	24
Bethlehem, Pennsylvania	140	47
Collinsville, Illinois	540	34
Danville, Virginia	1,490	22
Ft. Pierce, Florida	390	81
Front Royal, Virginia	900	5
Greeley, Colorado	700	22
Greene County, Ohio	380	40
LaCrosse, Wisconsin	710	49
Lebanon, Pennsylvania	180	28
Macon, Georgia	170	8
Salem, Oregon	1,150	40
Sheboygan, Wisconsin	670	125
Springfield, Ohio	520	22
York, Pennsylvania	1,360	73
AVERAGE	798	Weighted Average 37
AVERAGE Excluding Sheboygan	806	Weighted Average 32

Table 5

Dewatered Sludge Landspreading Cost Summary

Community	Dewatered Sludge Produced (Dry tons/yr)	Dewatering Cost ($/dry ton)	Total Cost ($/dry ton)
Vacuum Filter			
Anderson, Ind.	900	48	53
Appleton, Wisc.	7,700	25	42
Bethlehem, Pa.	460	110	120
Grand Rapids, Mich.	320	48	54
LaCrosse, Wisc.	3,650	68	81
Lawrenceville, Ill.	70	120	190
Louisville, Ky.	4,590	33	50
Rochelle, Ill.	1,950	75	89
Sheboygan, Wisc.	790	380	not available
Toledo, Ohio	16,250	77	117
York, Pa.	970	140	165
Average	3,205 weighted average	68	-
Average Excluding Sheboygan	3,366 weighted average	61	87
Drying Beds			
Belleville, Ill.	500	33	34
Grand Rapids, Mich.	2,930	7	15
Greeley, Colo.	500	8	8
Littleton, Colo.	510	12	13
Salt Lake City, Utah	1,410	1	1
Average	1,170 weighted average	8	12
Centrifuge			
Salt Lake City, Utah	6,500	20	20
Lagoon			
Springfield, Ohio	2,180	4	9

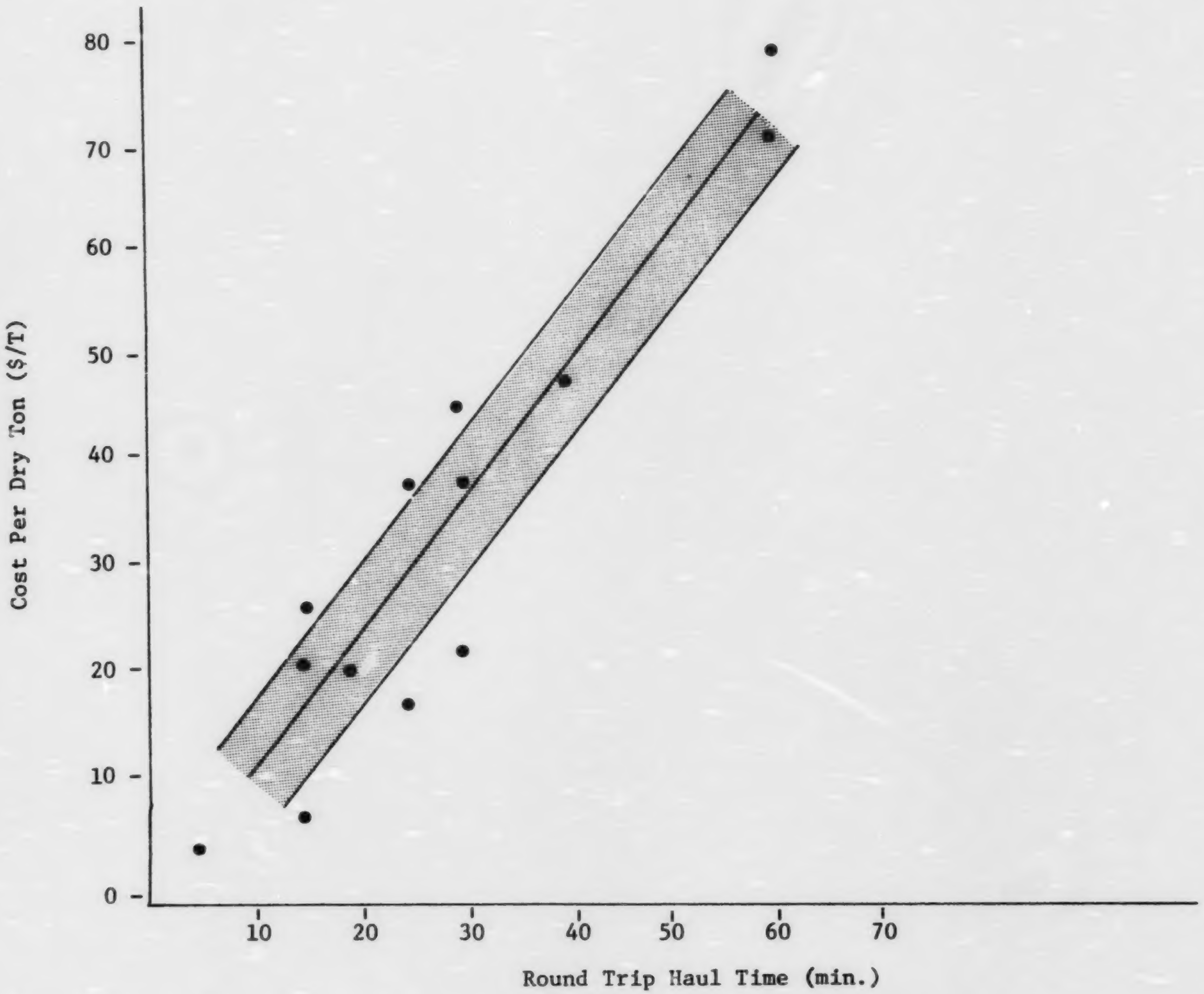

Figure 9--Cost of Haul Time for Liquid Sludge create the band on the figure with one standard deviation being ± $7.14 per dry ton at any point from the central line. A "t" test at 11 degrees of freedom indicates that the slope is significant at the 99 percent level. In determining the variance of a multiple regression, the data indicate that changes in haul time explain 91 percent of the variation in cost of disposal. As one might expect, then, haul time is a good prediction of a community's cost of disposing of its liquid sludge.

A similar analysis was performed comparing cost per ton excluding depreciation charges to haul time. A comparison of the results indicates that haul time is a better indicator of cost per dry ton when depreciation is included. As would be expected, the analysis also showed that depreciation is an important cost factor for those communities which have new transport vehicles.

For the liquid haul operations, the major cost category was personnel which accounted for an average of 42 percent of the total cost of sludge disposal. The next highest cost category was vehicle operation and maintenance with an average of 19 percent of the total followed by capital cost at 16 percent, fringe benefits at 14 percent and utilities and miscellaneous at 9 percent. Figure 10 illustrates the cost breakdown by major cost category.

2. Dewatered Sludge

a. Vacuum Filtration

Of the 24 plants visited, 16 dewatered part or all of their sludge. Eleven of the plants that dewatered sludge used vacuum filters in their normal operation with a weighted average dry ton disposal cost of $87. This cost varied between a low of $42 and a high of $190. If only the cost of dewatering sludge is considered, the average dry ton cost is $61 with a range of $25 to $140. In Sheboygan, the dewatering cost, using the City's figures, is $380 per dry ton. Figure 11 plots dewatering cost per dry ton versus annual dry tons processed while Figure 12 plots total cost for disposal of vacuum filtered sludge versus sludge volume. Because of the limited data, no attempt has been made to draw conclusions from these figures.

With vacuum filtration, the major average cost categories were personnel at 22 percent of the total cost, chemicals at 20 percent, and utilities at 16 percent. In addition, vehicle operation and maintenance, vacuum filter operation and maintenance, depreciation and fringe benefits each accounted for 9 to 12 percent of the total cost as shown in Figure 13.

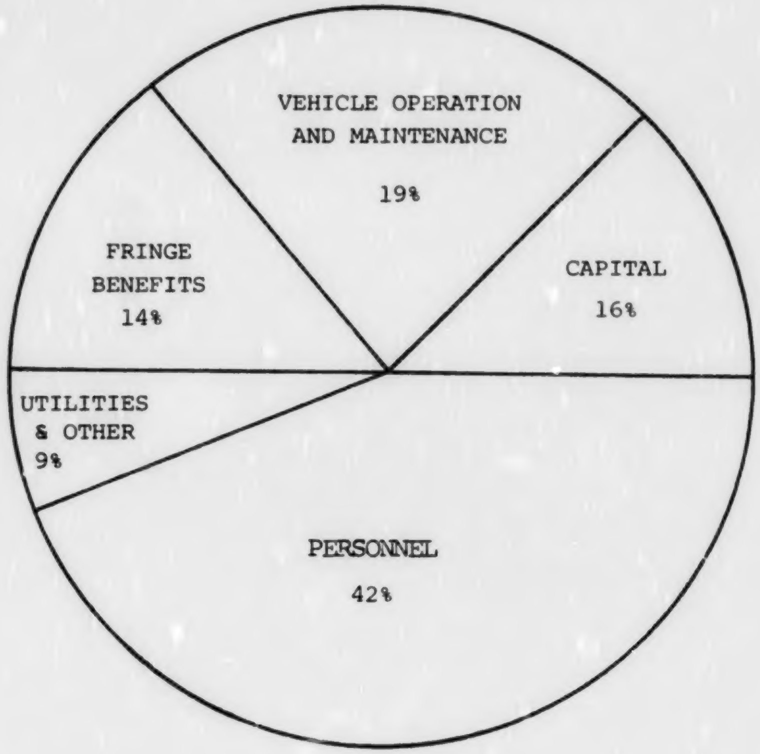

Figure 10--Breakdown of Total Annual Cost for Liquid Haul Systems

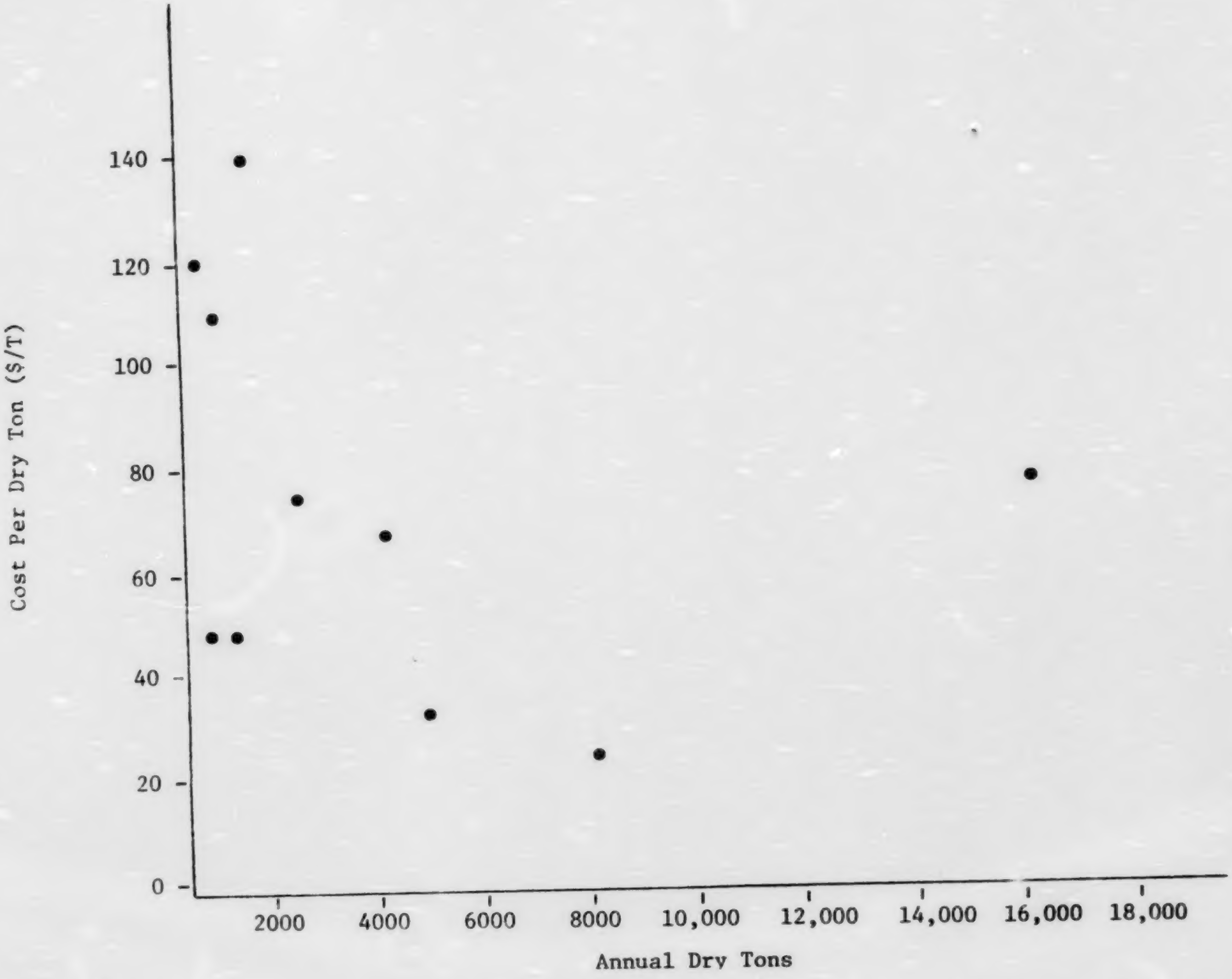

Figure 11--Cost for Dewatering by Vacuum Filtration

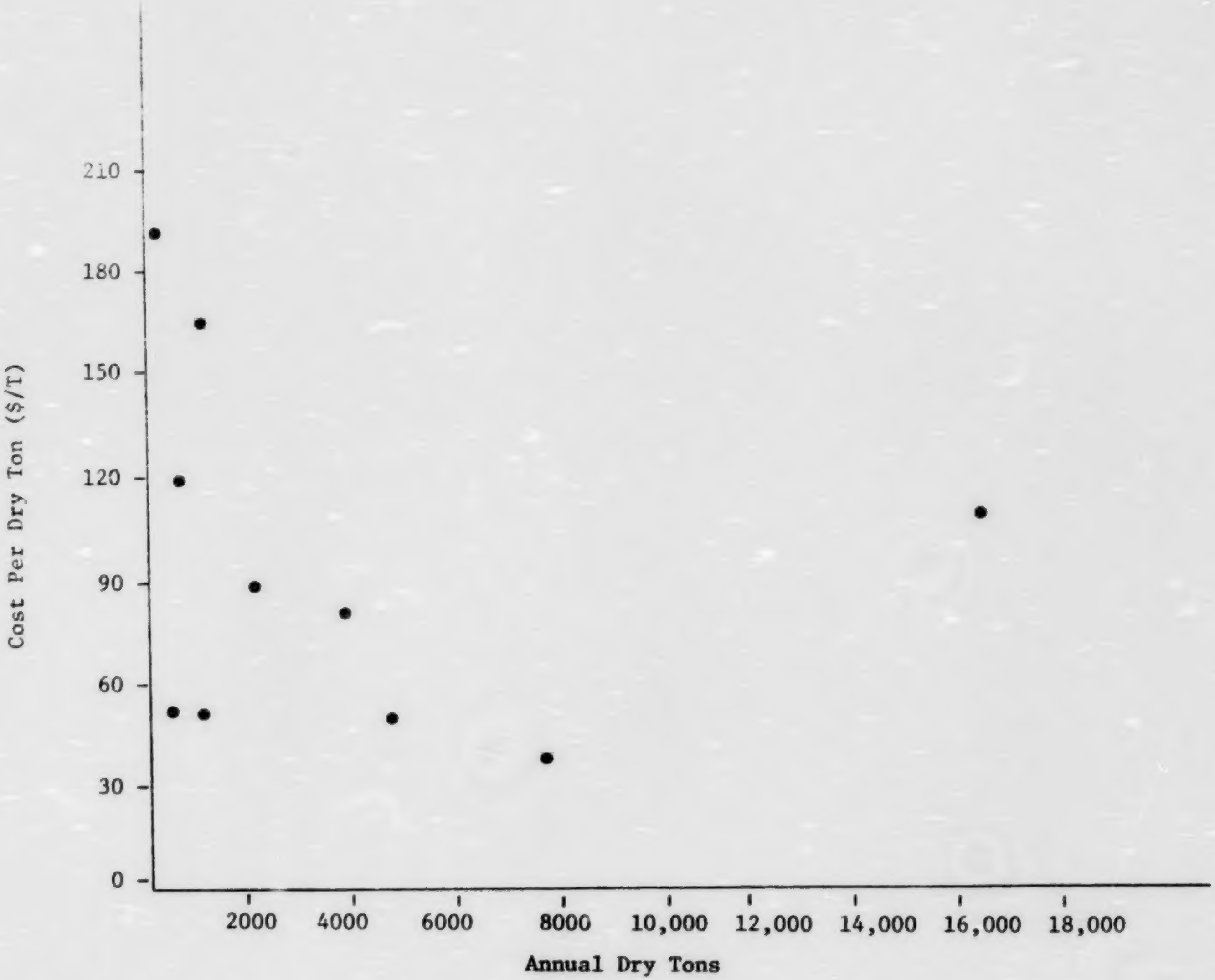

Figure 12--Cost for Disposal of Vacuum Filtered Sludge

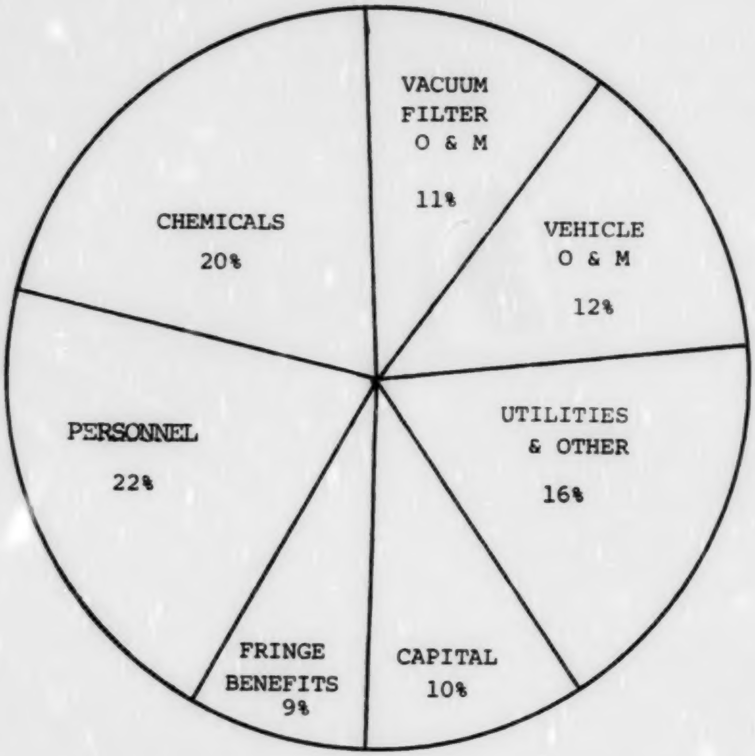

Figure 13--Breakdown of Total Annual Cost for Vacuum Filtered Sludge

2. Dewatered Sludge

b. Sand Drying Beds

Five of the plants dewatered part or all of their sludge on sand drying beds for an average dry ton disposal cost of $12. This cost varied between a low of one dollar per dry ton and a high of $34. If only the cost of dewatering the sludge is considered, the average dry ton cost is $8 with a range of one dollar to $33. Of the five plants, four have little or no cost for transporting and disposing of the sludge once it is removed from the beds since the dried sludge is used on plant property or stockpiled for removal by local citizens. Based on costs for other survey cities of comparable size with dewatered sludges, trucking away from the plant could easily increase these costs by $10 to $20 per dry ton. In addition, all of the drying beds were older installations that were fully depreciated and were, for the most part, only used on a part time basis. As a result there was usually very little maintenance work performed on the beds to keep them operating at their maximum efficiency. Because of these factors, the observed costs for the sand bed dewatering operation as well as the limited disposal costs encountered, amount to about one third of the predicted operation and maintenance cost for the dewatering operation.[1] Therefore, although the sand drying beds that were observed provided for a very inexpensive means to dewater sludge, they are not representative of newer nor continually utilized systems.

3. Comparative Cost Data

Of the cities surveyed, four (excluding Sheboygan) hauled both liquid and dewatered sludge (Anderson, Indiana; Bethlehem, Pennsylvania; LaCrosse, Wisconsin; and York, Pennsylvania). Table 6 presents data from these four communities.

This table shows that the cost for disposal of the average dry ton of sludge as a liquid was $38. However, for the same cities the cost for vacuum filtered sludge was $93. Therefore, on an average, the cities that used both methods paid almost two and a half times more per dry ton for the disposal of vacuum filtered than liquid sludge. The major reasons why these communities dewatered a portion of their sludge and liquid hauled the remainder were that they could not dispose of liquid sludge year-round because of either cropping practices or weather conditions. Some of the communities visited eliminated the traditional problem of only being able to spread liquid sludge during certain seasons by

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[1] "Sludge Processing Transportation and Disposal/Resource Recovery: A Planning Perspective, J. Michael Wyatt and Paul E. White, Jr., U.S.E.P.A. Contract No. 68-01-3104 by Engineering Science, Inc. (December 1975).

Table 6

Comparative Data on Four Cities

COMMUNITY	LIQUID		FILTERED	
	Quantity (dry tons/year)	Cost ($/dry ton)	Quantity (dry tons/year)	Cost ($/dry ton)
Anderson, Indiana	2,960	19	900	53
Bethlehem, Pennsylvania	140	47	460	120
LaCrosse, Wisconsin	710	49	3,650	81
York, Pennsylvania	1,360	73	970	165
Weighted Average	1,292	38	1,495	93

providing adequate sludge storage capacity at the plant. The storage capacity usually resulted from oversized digesters or from non-functioning digesters. While these storage facilities were usually older, fully depreciated structures, they not only provided flexibility for seasonal sludge disposal but also eliminated the need for a costly sludge dewatering operation.

APPENDIX

Data collection and case writing

by

R. Kent Anderson
Bruce R. Weddle
Ted Hillmer
Al Geswein

ANDERSON, INDIANA

The City of Anderson, Indiana is a community of approximately 76,000 population located about 30 miles northeast of Indianapolis, Indiana. The City's sewage treatment facility consists of a secondary activated sludge plant incorporating post chlorination of the effluent and anaerobic digestion of the sewage solids, followed by dewatering by vacuum filtration or direct application of liquid sludge to nearby farmland.

Persons Contacted

Mr. A. E. Hallinback
Superintendent

Mr. Chuck Bell
Industrial Monitoring
Department of Water Pollution Control
2801 Moss Island Road
Anderson, Indiana
Telephone (317) 646-5791

Site Description

Liquid Sludge Disposal - The City hauls liquid sludge to one of 30 different farms. Each disposal site varies in size and cropping practice and is selected from a list of farmers requesting the addition of sludge to their land. Because of the waiting list of farmers wanting sludge, only one application per year is normally made. Most of the sites receiving sludge are within 10 miles of the plant. During wet weather, sludge is transferred to a Big Wheels at the farm for spreading.

Vacuum Filtered Sludge - The City's vacuum filtered sludge is mainly stored on site for the public to pick up. Excess vacuum filtered sludge is hauled to the sanitary landfill.

General Information

The City estimates that industry contributes 44 percent of the plant flow. Most industries have pretreatment or are installing a pretreatment process. Major industries consist of two automotive related plants and a meat packing plant. The population equivalent of the plant--based on 0.17 lbs/BOD/person/day--is 100,000. The present design capacity is 22.7 MGD and the average daily flow is 18 MGD. The effluent is discharged into the White River. The treatment plant is presently undergoing reconstruction to include wet air oxidation.

All sludge leaving the plant receives secondary digestion. The City reported that in 1974, this amounted to approximately 10,000,000 gallons at 9.3 percent solids (i.e., 10.5 dry tons/day).

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Sewage Sludge Composition

Table 1 presents data on the composition of the Anderson sludge. The solids content of the liquid sludge is 9.3 percent and of the dewatered sludge is 26.1 percent.

Transport System

Liquid Sludge - The City currently liquid hauls the majority of its sludge. The decision to vacuum filter or liquid haul is solely dependent upon the availability of a readily accessible field. Liquid sludge is hauled an average of 5 1/2 days per week. The City has been hauling liquid sludge for the past 12 years. The transport vehicles consist of five 1,400 gallon tank trucks and one 1,500 gallon Big Wheels for use in wet fields. The Big Wheels is only used on a farm during wet weather for spreading sludge pumped into it from tank trucks.

In 1974, a total of 5,453 loads of sludge were hauled with an average total haul time of 52 minutes. Five drivers and five trucks are used approximately half time as a yearly average to haul liquid sludge. The average round trip distance to disposal sites is about 11 miles with an average driving time of about 25 minutes. Loading time amounts to about 4-5 minutes and about 22 minutes to unload. The trucks are equipped with a fan-shaped, gravity flow spreading device.

Vacuum Filtered Sludge - Because of the high cost of maintenance, chemicals and labor to operate the vacuum filters, they are only used when conditions are not conducive to liquid hauling and the plant cannot store additional sludge. In 1975, the vacuum filters were only operated one day. In 1974, the year on which our analysis is based, the vacuum filters were operated 1,169 hours. The dried sludge is mainly stockpiled close-by, on site for private individuals to pickup for garden use. Excess dried sludge is hauled to the sanitary landfill. The City has two 2 1/2 cubic yard dump trucks which are for hauling filtered sludge, grit, and screenings.

Landspreading System

Most liquid sludge is applied by the tank truck directly on the fields by a gravity flow system through a fan-shaped spreader nozzle. However, when fields are wet, the sludge is pumped from the tankers into a Big Wheels for spreading. The Big Wheels uses a pressurized unloading system. Because of the demand for sludge, most fields only receive one application per year. The normal application rate is 10,000 gallons per acre (4 dry tons/acre). The principal crops grown on land receiving sludge are corn and soybeans. A sod farm and airport grounds also receive liquid sludge. The City does not charge the farmers for sludge.

Costs

The 1974 cost to the City for disposal of 2,960 dry tons of liquid sludge was $19 per dry ton. In comparison, the City's cost for disposal of 900 dry tons of vacuum dried sludge was $53 per dry ton. With the vacuum filtered sludge, the cost of dewatering accounts for about $48 per dry ton. The major cost items for dewatering are depreciation of the vacuum filters at about $14,730, personnel costs of over $14,000, and chemical costs of about $5,400. A breakdown of how these costs were determined is attached.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$ 9,490	
1970 Ford, cost: $9,148		
1970 Ford, cost: $9,148		
2 1973 Fords, cost: $7,800		
1974 Chevy, cost: $3,898		
1974 GMC Big Wheels, cost: $25,954		
Total Annual Capital Cost		$ 9,490

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
5 Truck Drivers	$4.62	46	$21,970	
Chemist	3.61	3	220	
			$22,190	
Fringe Benefits (30 percent)			$ 6,650	
Vehicle Maintenance and Operation			$12,620	
Utilities			$ 20	
TOTAL ANNUAL OPERATING COST				$41,490
TOTAL ANNUAL CAPITAL AND OPERATING COST				$50,980
10 PERCENT CONTINGENCY FACTOR [2]				$ 5,100
TOTAL ANNUAL COST				$56,080

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$56,080}{2,960 \text{ dry tons}} = \$19 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] A 10 percent contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF VACUUM DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$ 320	
1969 Dump Truck, cost: $4,400		
1972 Dump Truck, cost: $4,952		
Stationary Equipment Depreciation [2]	$14,730	
Vacuum Filters, cost: $101,110		
Total Annual Capital Cost		$15,050

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
4 Operators	$4.62	30	$11,460	
Truck Driver	4.62	30	2,860	
			$14,320	
Fringe Benefits (30 percent)			$4,120	
Vehicle Maintenance and Operation			$ 180	
Vacuum Filter Maintenance				
Chemicals			$5,390	
Parts and Repair			3,500	
Utilities			$1,000	
TOTAL ANNUAL OPERATING COST				$28,516
TOTAL ANNUAL CAPITAL AND OPERATING COST				$43,560
10 PERCENT CONTINGENCY FACTOR [3]				$ 4,360
TOTAL ANNUAL COST				$47,920

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$47,920}{900 \text{ dry tons}} = \$53 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] Stationary equipment was depreciated over 10 years at 8 percent interest, which amounts to a depreciation charge of $12.13 per $1,000 per month.

[3] A 10 percent contingency factor is added to cover such items as administrative overhead.

TABLE 1

HEAVY METAL ANALYSIS ON ANDERSON DIGESTED SLUDGE

FALL 1975

	Samples						
	1	2	3	4	5	6	7
TS[2]	8.56	5.98	6.12	5.55	8.04	7.34	7.66
Cu	14,350[1]	12,860	12,440	10,520	10,210	7,400	6,970
MN	276	193	204	146	173	190	170
ZN	9,100	6,250	9,420	12,940	12,620	15,720	17,040
CR	11,040	12,510	13,080	10,320	11,630	8,680	6,080
Pb	1,130	166	338	583	842	579	503
Fe	16,000	19,870	13,170	15,170	14,850	11,000	8,130
Ni	1,140	1,030	1,330	2,100	2,480	1,740	1,550
Cd	255	212	201	162	229	223	170
Mo	14	18	9	8	10	7	8
AL	28	31	24	29	37	29	23
SN	NA[3]	NA	293	65	99	116	93
Co	NA	NA	41	32	74	21	39
Ag	NA	NA	14	1	19	12	39
Sb	NA	NA	5	5	8	2	1
As	NA	NA	9	1	1	1	1

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[1] All results reported in ppm dry solids

[2] Total Solids

[3] Not Analyzed

APPLETON, WISCONSIN

Appleton is a community of approximately 58,000 people that is located 100 miles north of Milwaukee, Wisconsin. The area is served by one treatment facility which consists of a secondary activated sewage treatment process incorporating both pre and post-chlorination, and partial (25 percent) anaerobic digestion of the resulting solids. After digestion, the sludge is vacuum filtered and hauled by a private contractor to local farmland. Permits are required by the Lake Michigan Department of Natural Resources before the sludge can be applied to the land.

Persons Contacted

Mr. Wayne Colbert
Wastewater Superintendent
City Hall
225 North Oneida Street
Appleton, Wisconsin 54911
Telephone: (414) 739-4396

Mr. Richard B. Van Handel
Sludge Contractor
2435 East Edgewood Drive
Appleton, Wisconsin 54911
Telephone: (414) 734-1272

Site Description

The City's dewatered sludge is hauled by a contractor to several different site locations for disposal. Each disposal site varies in size and cropping practice, and is selected from a list of farmers requesting sewage sludge for use on their land. The sludge is hauled 362 days of the year. An application of approximately eight inches of sludge is placed on each farm per year. The soil in this area is an Allendale loamy fine sand.

General Information

Industrial input into the City's treatment facilities was estimated to be approximately 30 percent of the total daily flow. The design capacity of the plant is 20 MGD for the primary stage and 12 MGD for the secondary stage. The average daily flow is 12 MGD. The effluent is discharged directly into the Fox River, which eventually drains into Lake Winnobago. With the present plant design, it is obvious that this system cannot handle peak flows. Because of this situation, the City is currently in the midst of a plant expansion program to upgrade the total facility. The present system of landspreading sludge will continue with the proposed expansion.

The total quantity of primary and secondary activated sludge generated amounts to 7,700 tons per year of filter cake. The sludge comes off the vacuum filter at 20 to 22 percent solids. The total amount of cake leaving the plant after partial digestion is 47,680 cubic yards per year. This partial digestion results from the fact that the digesters are old and do not function properly. Therefore, three of the four digesters are utilized for storage with the remaining digester operating "normally." The reduced retention time in the operating digester results in about a 25 percent reduction of the sludge.

Based on national per capita sludge generation figures, the City of Appleton, Wisconsin, should be generating approximately 5.2 dry tons of solids per day. This is not the case, however. It was reported that the City generates on the order of 21 dry tons per day. This results from the industrial contribution (Appleton is the home of a paper mill and a sugar beet cannery that operates six months of the year) and the plant design, which requires the use of 1,050 tons of lime each year.

Sewage Sludge Composition

Table 1 presents data relative to the metals content of Appleton sludge. Samples were taken by Badger Laboratories and Engineering on September 16, 1975, and analyzed for several heavy metals. The sludge is high in some metals (i.e., copper, lead, cadmium, and chromium).

Transport System

The method used for hauling filter cake and spreading is somewhat unique. From the "digesters" (i.e., storage tanks), the liquid sludge is pumped to the vacuum filters where the dewatering occurs. The cake then drops onto a conveyor belt which takes it to an enclosed concrete slab adjacent to the vacuum filter building. Here, a front end loader scoops the cake from the concrete area into a dump truck. The transport vehicles used include: one four wheel drive six by six, used on wet fields; one Ford 5-axle, used on dry or frozen fields; one Ford dumptrailer, used in hauling; two blade dozers used in spreading the sludge; and one four wheel drive tractor, used in plowing the sludge under.

Landspreading System

The dewatered sludge is hauled by dump trucks to farmland, with the driver of the dump truck also being responsible for spreading his load with the blade dozer vehicle. After spreading of the sludge has taken place, the sludge is plowed under, usually on the same day as the spreading. Although there have been some complaints concerning odors before the sludge is plowed under, the odors are minimal when compared with raw animal manure solids that are collected, stored, and applied by farmers to their own land. All these services--hauling, dumping, spreading, and plowing--are provided by the hauler at no cost to the farmer. However, it is possible that in the future, some costs could be encountered by the farmer to cover added transportation for long distance hauls.

Most of the City's sludge is being hauled to corn fields. Applications are only made after the field is cropped or before spring planting. Of the 350 acres that are available for spreading, it is estimated that half (175 acres) is utilized by the City of Appleton to dispose of their sludge, with the remainder of the acreage being used by the City of Neenah-Menasha. Based on figures provided by the plant, it can be calculated that the Appleton area farmers receive 44 dry tons per acre per year. Crop yields on fields which had received sludge that year were reduced, apparently because of the high metals content of the sludge and also its high pH, caused by the large lime content. Two years after a one-time application of sludge, crop yields were dramatically increased.

Cost

Based on actual operating information provided by representatives of Appleton, the City was disposing of its sludge in 1974 at a cost of $42 per dry ton of solids, with operating time of the vacuum filter being 16 hours a day, 7 days a week. Of this, the cost of dewatering amounted to about $25 per dry ton. Major costs items for dewatering included chemicals, which cost over $70,000, and personnel, nearly $47,000. The contractor cost was $2.25 per yard hauled in 1974. However, in 1975, the cost rose to $4.00 per yard hauled. This would increase the disposal cost to $54 per dry ton of solids. A more detailed cost breakdown of the variable and fixed costs is attached.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation	0	
Plant Equipment Depreciation	0	
Total Annual Capital Cost		0

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
Vacuum Filter Operator	$5.00	100	$10,400	
Vacuum Filter Operator	5.30	100	11,020	
2 Lime Room Laborers	4.86	100	20,220	
Assistant Superintendent	6.15	30	3,840	
Superintendent	6.97	10	1,450	
			$46,930	
Fringe Benefits at 30 percent			$14,080	
Vacuum Filter Operation and Maintenance				
Chemicals				
Lime			$46,980	
Ferric Chloride			25,420	
Acid			1,240	
Parts and Repair			21,300	
Vehicle Operation and Maintenance				
Contract Hauling (@ $2.25 per yard)			$107,220	
Utilities (gas and water)			$33,240	
TOTAL ANNUAL OPERATING COST				$296,410
TOTAL ANNUAL CAPITAL AND OPERATING COST				$296,410
10 PERCENT CONTINGENCY FACTOR[1]				29,640
TOTAL ANNUAL COST				$326,050

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$326,050}{7,700 \text{ dry tons}} = \$42 \text{ per dry ton}$$

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[1] A 10 percent contingency factor is added to cover such items as administrative overhead.

TABLE 1

Sludge Sample Taken September 16, 1975

Badger Laboratories and Engineering
Stephen Taylor, Chief Chemist

Percent Solids	18.6 %
Percent Ammonia Nitrogen	0.11%
Organic Nitrogen	2.70%
Percent Total Nitrogen	2.81%
Phosphorus	2,916 ppm
Potassium	123.1 ppm
Chromium	734.9 ppm
Copper	534.6 ppm
Lead	764.1 ppm
Zinc	70.2 ppm
Cadmium	111.2 ppm
Mercury	0.011 ppm
Nickel	88.0 ppm

Figures are reported on a dry weight basis.

BELLEVILLE, ILLINOIS

The City of Belleville, Illinois is a community of approximately 41,700 population, located 15 miles southeast of St. Louis, Missouri. The City's largest sewage treatment facility consists of a secondary activated sludge plant incorporating post chlorination of the effluent and anaerobic digestion of the sewage solids, followed by air drying and/or direct application of liquid sludge to nearby farmland.

Person Contacted

Mr. George Hankammer
Superintendent of Treatment
Plant Operations
Belleville, Illinois 62220
Telephone: (618) 233-6810

Site Description

Liquid Sludge Disposal - The City hauls liquid sludge to one of several different site locations. Each disposal site varies in size and cropping practice and is selected from a list of farmers requesting the addition of sludge to their land. Any farmer within a reasonable haul distance (i.e., 5-10 miles) who desires to have sludge placed on his land may place a request with the City and if conditions are suitable (i.e., weather, season of the year, site accessibility, etc.) the wastewater treatment plant will make one or two applications of sewage sludge to his land.

Air Dried Sludge - The City's air dried sludge is stored in a small designated area adjacent to the main treatment plant property. The area is located just outside a fenced area that surrounds the plant, thus enabling persons desiring the sludge to pick it up at their leisure. No regulation or other controls are placed upon the use or the amount of sludge an individual may take. According to one City official, "the pile just seems to gradually erode away."

General Information

The City Superintendent of Treatment Plant Operations estimated the industrial input into the City's treatment facilities to be approximately 40 percent of the total flow. The population equivalent, based on a BOD of 0.17 lbs BOD/cap/day, is calculated at 76,000. The overall treatment plant design capacity is rated at 6.0 MGD with an average flow of 5.5 MGD. The effluent is discharged directly into a very small stream that drains into the Kaskaskia River.

The plant effluent often exceeds the normal stream flow in the creek. To improve the effluent quality, the City is currently in the midst of upgrading the facility to include tertiary treatment. After completion, the City intends to dispose of its sludge by dewatering with a centrifuge and stockpiling the sludge for citizens to remove. The centrifuge is scheduled to come on line shortly after January 1, 1976.

The combined quantity of primary and secondary activitated sludge generated today totals approximately 33,000 gallons/day at 4.3 percent solids (i.e., 5.9 dry tons/day). The total sludge leaving the plant after digestion averages 15,000 gallons/day at 3.8 percent solids (i.e., 2.4 dry tons/day or 880 dry tons/year). This represents a 60 percent reduction in total solids generated. This is an extremely high reduction in solids content as digestion typically results in only a 35 to 40 percent reduction in solids. It can be explained by the somewhat unique nature of the industrial contributors (i.e., slaughterhouse waste, brewery plant, hospital, and a paper box manufacturer). Based on the type of treatment provided, a more reasonable estimate as to the total solids disposed annually in the City of Belleville should be 1,000 dry tons/year, or approximately .14 lbs/cap/day.

Sewage Sludge Composition

Table 1 presents data on the metals content of the liquid sludge. Samples were taken from one of the two large secondary digesters on January 14, 1974 and analyzed for a comprehensive list of heavy metals. As displayed, the sludge is fairly low in all metals. This is probably due to the fact that the industrial contributors are not major heavy metal pollutors. One possible exception is a relatively large enamelling plant. However, no specific data as to the amount or characteristics of the industrial waste from this plant were available.

Transport System

Liquid Sludge - The City currently liquid hauls half of its sludge and has been doing so for the past five or six years. The decision to air dry or liquid haul is solely predicated upon the availability of a readily accessible field, weather conditions, season of the year, and the haul distance to the site. In general the City liquid hauls its sludge at 3.8 percent solids 10 to 12 weeks out of the year. The transport vehicles consist of two 2,000 gallon tank trucks. One was purchased in 1971 at a cost of $9,000 and the other is a 1966 vehicle purchased at a cost of $6,000.

It was reported that on days that sludge is hauled an average of 20 loads of liquid sludge are removed from the plant. Two drivers and two vehicles are used essentially full time during the periods when sludge is liquid hauled (i.e., early spring and late fall). The average haul distance is approximately six miles one way with an average round trip driving time of 20 minutes. The vehicles take approximately 10 minutes to load and 15 minutes to unload. They are not equipped with a pump, spreading "T" or any other device to aid spreading or distribution capability. The City's two large anaerobic digesters are used for storage (i.e., 1.7 million gallon combined capacity).

Air Dried - The only transport system involved in handling the air dried sludge is a 1966, 1 1/2 ton Ford dump truck with a three cubic yard body purchased at a cost of $2,800. There is no significant haul time involved, as the vehicle is loaded and then only travels several hundred feet before it offloads.

The air drying beds collectively encompass an area of 2.75 acres of actual drying surface and include an additional 2.25 acres of miscellaneous area (i.e., roadways, green area, etc.). Each drying bed holds a maximum of 100,000 gallons of sludge at 4 percent solids (i.e., 15 dry tons of solids or about one weeks worth of sludge). Each of the 11 individual drying beds are covered at least three times each year. The land was purchased in 1942 at a value of approximately $40/acre. No information was obtained relative to the actual cost of constructing the air drying beds.

Landspreading System

Liquid Sludge - The liquid sludge is applied by gravity flow directly from the rear of the truck. The City has experimented with pumps and hoses but found it easier and more appealing to the driver to simply let the sludge drain out onto the ground. Each 2,000 gallon load covers an area of 2500 to 3000 square feet which results in an application rate of five to six dry tons per acre (i.e., 1000 feet long by 2 1/2 to 3 feet wide). No problems of odors or flies were noted, even though the sludge is not always turned under immediately after application. The farmer usually turns the sludge into the soil at no cost to the City after the field has been fully covered.

The City has been and is currently hauling most of its liquid sludge to corn and soybean fields. Applications are only made after the field is cropped or before the spring planting. There have been several overtures to the City to haul its sludge to an abandoned strip mined area northeast of the City. However, because of the excessive cost and haul distance, no further progress has been made in the area.

Cost

The City currently employs 22 fulltime employees at its main treatment plant. The total operating budget for 1974 amounted to $325,549. The salaries and wages accounted for over 65 percent of the annual operating cost.

The City is currently disposing of its sludge at an average cost of $29 per ton of dry solids. The air drying operation is the more costly of the two systems (i.e., air drying and liquid haul) because of the added cost of dewatering and the labor intensive cleaning operation to remove the sludge from the drying beds. It is estimated that the air drying system (excluding the capital and maintenance cost of the drying beds) cost the city $34 per ton of dry solids disposed. The liquid haul and spread operation appears to be the least costly of the two systems, accounting for only $24 per dry ton of solids disposed. A more detailed cost breakdown of the capital and operating costs for each option follows.

COST FOR DISPOSAL OF AIR DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation	0	
Equipment Depreciation	0	
Total Annual Capital Cost		0

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Equipment Operator	$5.60	20	$2,330
Laborer	4.77	20	1,980
STP Operator	5.40	11	1,240
Foreman	6.25	0.8	100
			$7,630

Fringe Benefits at 25 percent	$1,910	
Vehicle Maintenance and Operation		
Repairs	$1,420	
Fuel, Oil, and Insurance	950	
	$2,370	
Utilities and Other		
Electricity	$ 100	
Pumps, Motors and Misc. Equipment	210	
Supplies (chemical polymers)	3,960	
Maintenance on Beds	300	
	$4,570	
TOTAL ANNUAL OPERATING COST		$16,480
TOTAL ANNUAL CAPITAL AND OPERATING COST		$16,480
10% CONTINGENCY FACTOR[1]		$ 1,650
TOTAL ANNUAL COST		$17,130

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$17,130}{\text{500 dry tons}} = \$34 \text{ per dry ton}$$

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[1] A 10 percent contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$2,550	
1969 Ford: Cost, $6,000		
1971 Ford: Cost, $9,000		
Total Annual Capital Cost		$ 2,550

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
Truck driver	$5.25	36	$3,930	
Superintendent	6.25	0.5	650	
Fringe Benefits at 25 percent			$1,150	
Vehicle Maintenance and Operation				
Repairs			$1,420	
Gasoline, Oil, and Insurance			950	
			$2,370	
Utilities and Other				
Electrical Power			$ 100	
Pumps, Motors and Misc. Equipment			210	
TOTAL ANNUAL OPERATING COST				$ 8,310
TOTAL ANNUAL CAPITAL AND OPERATING COST				$10,960
10% CONTINGENCY FACTOR [2]				$ 1,100
TOTAL ANNUAL COST				$12,060

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$12,060}{\text{500 dry tons}} = \$24 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

Table I

Sludge Sample*
January 14, 1974 - Compiled by Peabody Company

pH -	7.2
Total solids -	5.58%
Volatile solids -	2.64%
Kjeldahl N -	7.7%
Ammonia (NH) -	2.9%
Organic N -	4.8%
NO -	0%
Total N -	7.7%
SO -	0 ppm
Cl -	8,600 ppm
Br -	54 ppm
Fl -	52 ppm
Hardness -	896,060 pppm as $CaCo_3$
Acidity -	16,880 ppm as $CaCO_3$
Alkalinity -	324,190 ppm as $CaCO_3$
COD -	400,140 ppm
Ca -	20,660 ppm
Mg -	7,490 ppm
Na -	3,570 ppm
Phosphorous -	6,990 ppm
K -	2,220 ppm
Al -	5,380 ppm
Cu -	290 ppm
Ni -	270 ppm
Mn	900 ppm
Fe -	33,510 ppm
Zn -	1,300 ppm
Cd -	10.7 ppm
Cr -	2.5 ppm
Pb -	1,340 ppm
Hg	3.0 ppm

*On a dry weight basis

BETHLEHEM, PENNSYLVANIA

Bethlehem, Pennsylvania is located on the eastern border of the State approximately 60 miles north of Philadelphia. The City wastewater treatment plant utilizes anaerobic digestion and serves a population of 100,000. Sewage solids from the plant are transported in both the liquid and vacuum filtered form to either farmland or to a sanitary landfill.

Person Contacted

Mr. William H. Grim
Superintendent of Wastewater Treatment
Department of Public Works
10 East Church Street
Bethlehem, Pennsylvania 18018
Telephone: (215) 865-7168

Site Description

Over the past seven years of landspreading, approximately 1500 acres of farmland east of the City have received sludge. However, no records were kept showing which land had received sludge, nor the quantities applied.

General Information

The wastewater treatment plant was constructed in 1952 and has a design capacity of 12.5 MGD. The present average daily flow is 12.0 MGD. Industry contributes about 40 percent of this flow. The primary industrial contributors are a textile mill, a hospital, three metal plating plants, a dextrose manufacturer, and several commercial laundries. Wastes from the dextrose plant and commercial laundries cause some problems in the operation of the plant (from grease and high solids content in their wastes), although these are not serious. Two of the three metal platers pretreat their wastes.

After being anaerobically digested the City's sewage sludge is hauled directly to land as a liquid at 4.5 percent solids or vacuum filtered to 20 to 25 percent solids and hauled by dump truck to the City's landfill or to farmland. The total dry weight of sludge leaving the plant in 1974 was 600 dry tons. Of this, 140 dry tons were applied as a liquid and 460 dry tons were dumped and spread as vacuum filtered sludge.

Sewage Sludge Composition

No sludge analysis was available.

Transport System

The vacuum filtered sludge is generally hauled to a sanitary landfill five miles from the plant. On occasion, however, it is hauled to farmland if there is a site available. All liquid sludge is applied to farmland.

The average round trip distance to the landspreading site is nine miles while it is 10 miles round trip distance to the sanitary landfill. The average round trip travel time to both sites is 30 minutes. The apparatus for loading the trucks consists of a belt conveyor from the vacuum filters to the dump truck and a gravity flow stand pipe for the liquid sludge.

Landspreading System

Liquid Sludge - Liquid sludge is transported and applied to farmland by a 2,000 gallon tank truck. The truck is equipped with a "T" distribution pipe for unloading by gravity flow while being driven across the field. The average time for unloading the truck is 9 minutes. Because no records are kept of the acreage receiving sludge nor the frequency of application, it is not possible to determine the application rate. At the time of the visit, farmers were not eager to receive sludge because of a recent Pennsylvania State University study which pointed out potential problems with sewage sludge due to heavy metals.

Vacuum Filtered - Most of the vacuum filtered sludge was hauled to the sanitary landfill. However, when farmland is available, it is normally dumped in a corner of the field for the farmer to distribute with his manure spreader. If crops are not on the fields, the sludge is dumped in piles across the field for the farmer to spread with a blade.

Cost

Based on actual operating information provided by the City, the 1974 cost for liquid sludge disposal was $47 per dry ton and for vacuum filtered sludge was $120 per dry ton. With the vacuum filtered sludge, the cost of dewatering accounts for nearly $110 per dry ton. The major reasons for high dewatering cost are that repairs on the older vacuum filters cost about $25,000 and labor to operate them costs over $16,000. A more detailed cost analysis is presented on the following pages.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	$1,650	
1969 Ford tank truck, Cost: $9,460		
Stationary Equipment Depreciation	0	
Building Depreciation	0	
Total Annual Capital Cost		$1,650

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Truck driver	$3.31	15	$1,030
Auto Mechanic	5.00	1	100
Chief Operator	6.38	6	830
Superintendent	7.93	3	500
Total Personnel Cost			$2,460

Fringe Benefits at 44 percent	$1,080	
Vehicle Maintenance and Operation:		
Repairs	$ 390	
Fuel and Oil	230	
Insurance	130	
Utilities	0	
TOTAL ANNUAL OPERATING COST		$4,290
TOTAL ANNUAL CAPITAL AND OPERATING COST		$5,940
10% CONTINGENCY FACTOR[2]		$ 590
TOTAL ANNUAL COST		$6,530

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$6,530}{140 \text{ dry tons}} = \$47/\text{dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	$ 0	
Equipment Depreciation[2]	0	
Building Depreciation[3]	0	
Total Annual Capital Cost		$ 0

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
2 Vacuum Filter Operators	$4.08	41	$ 8,560
Clean up	3.31	15	1,030
Truck Driver	3.31	30	2,060
Auto Mechanic	5.00	3	290
Chief Operator	6.38	19	2,490
Superintendent	7.93	2	330
Total Personnel Cost			$14,760
Fringe Benefits at 44 percent			6,500
Vehicle Maintenance and Operation			
Repairs			550
Fuel and Oil			240
Insurance			260
Vacuum Filter Maintenance			
Chemicals			1,360
Parts and repair			25,000

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1000 per month.

[3] Buildings were depreciated over 20 years at 8% interest which amounts to a depreciation charge of $8.36 per $1000 per month.

Utilities	1,600	
TOTAL ANNUAL OPERATING COST		$50,270
TOTAL ANNUAL CAPITAL AND OPERATING COST		$50,270
10% CONTINGENCY FACTOR [4]		$ 5,030
TOTAL ANNUAL COST		$55,300

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$55,300}{460 \text{ dry ton}} = \$120/\text{dry ton}$$

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[4] A 10% contingency factor is added to cover such items as administrative overhead.

COLLINSVILLE, ILLINOIS

The City of Collinsville, Illinois is a community of approximately 20,000 population located 10 miles east of St. Louis, Missouri. The City's wastewater treatment facility consists of a tertiary system with post chlorination of the effluent and secondary aerobic digestion of the sewage solids. Digested sludge is stored in ponds awaiting application to farmland.

Person Contacted

Mr. Francis Vacca, Superintendent
Wastewater Control Plant
300 Simpson Street
Collinsville, Illinois 62234
Telephone: (618) 344-0304

Site Description

The City hauls liquid sludge to several different site locations. Each disposal site varies in size and cropping practice and is selected from a list of farmers requesting the addition of sludge to their land. The farmers who now receive sludge are located adjacent to the wastewater treatment facility. There are ten farm plots totaling 199 acres, that range in size from 8 to 31 acres of available land. In the future, the superintendent plans to haul to any farmer located within a five mile haul distance.

General Information

The City superintendent of treatment plant operations estimated the industrial input into the City's treatment facilities to be about one percent of the total flow. The overall treatment plant design capacity is rated at 3.5 mgd with an average daily flow of only 1.2 mgd. The effluent is discharged directly into a small stream - Canteen Creek - which drains into the Mississippi River. In 1972, the City constructed its present facility incorporating tertiary treatment with aerobic digestion.

The combined quantities of primary and secondary activated sludge totals 540 dry tons per year. The sludge is pumped to one of several holding ponds prior to being transported and applied by a Big Wheels tank truck.

Sewage Sludge Composition

Table 1 presents data relative to the metals content of Collinsville sludge. As displayed, the sludge is fairly low in metals except iron (i.e., 27,148 ppm). This is probably due to infiltration into the collection system, street runoff, and ground runoff from the rocky hills around the area.

Transport System

The City currently liquid hauls all of its digested sludge. The limitation of when one can haul has been greatly minimized due to the purchase of a Big Wheels vehicle. The Big Wheels vehicle, which consists of a 1600 gallon tank on a GMC chassis is equipped with high flotation terra-tires that virtually eliminate the traditional problems of ruts, compacted soil, and crop damage. The vehicle was purchased in 1975 at a cost of $35,000.

It was reported that an average of 13 loads per month of liquid sludge at 8 to 10 percent solids is hauled from the plant. The average haul distance is one mile and the load and unload time are both five minutes. The truck is loaded by utilizing a pump on the truck to pump the sludge from the two ponds which hold 960,000 gallons. With this short haul distance, as many as 15 loads per day can be handled by the truck. As a result, all the sludge produced at the plant can be hauled in an average of one day per month. On haul days, two drivers are utilized, one working 80 percent of the time and the other 20 percent.

Landspreading System

The City has experimented with various systems and private contractors but has found it easier and more appealing to utilize the Big Wheels. This truck is equipped with a pressurized rear spray system with each load covering an area of 25 to 30 feet by 1000 feet. Sludge is applied at a rate of about one dry ton per acre. In some cases two or three applications will be made per year. The sludge is turned under by the farmer within 24 hours of application. There have not been any problems with odors or flies. To date, sludge has been applied to wheat and soybean fields.

Cost

The City currently has seven fulltime employees at the treatment facility. The total operating budget for the sewage collection system and the treatment plant is $270,000.

It is difficult to develop realistic costs on this system because the new treatment plant has only been in operation a short period, and they do not haul all the sludge that is currently being produced. The lagoons which are used to store the digested sludge are new and therefore can be utilized as a holding area until they reach maximum capacity. During this storage process the liquid from the lagoon is recirculated to the front of the plant. Furthermore, a portion of the water evaporates. Thus when the sludge is pumped from the lagoon to the vehicle, the percentage of solids has increased from 3 to 4 percent to approximately 8 to 10 percent.

Because the City is stockpiling a portion of its sludge, any cost analysis based on only the amount actually being hauled would be very misleading. Therefore this analysis is based on the City hauling their entire sludge production of 540 dry tons (which the City will be hauling once the lagoons are filled).

Based on information provided by the City of Collinsville and vehicle maintenance and operational costs provided by the truck manufacturers, the City's cost for disposing of its total annual sludge quantity (excluding the costs of the lagoons) is $34 per dry ton.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]		$ 5,940	
1975, GMC - Big Wheels, cost:	$35,000		
Total Annual Capital Cost			$ 5,940

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$5.31	40	$ 4,420
Driver's Assistant	5.31	10	1,100
Chemist	5.41	2	240
Secretary	2.50	2	100
Superintendent	5.70	5	590
			$ 6,450

Fringe Benefits at 33 percent	$ 2,130
Vehicle Maintenance and Operation:	
Gasoline	$ 1,170
Oil	140
Insurance	320
Maintenance	600
	$ 2,230

TOTAL ANNUAL OPERATING COST	$10,810
TOTAL ANNUAL CAPITAL AND OPERATING COST	$16,710
10% CONTINGENCY FACTOR [2]	$ 1,680
TOTAL ANNUAL COST	$18,430

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$18,430}{540 \text{ dry tons}} = \$34 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

TABLE 1

SLUDGE ANALYSIS *

Barium	479	ppm
Cadmium	16	ppm
Chromium, Trivalent	64	ppm
Copper	260	ppm
Lead	345	ppm
Manganese	701	ppm
Nickel	58	ppm
Silver	34	ppm
Zinc	1,585	ppm
Chromium	0.06	ppm
Mercury	0.06	ppm
Iron	27,149	ppm
Ammonia as N	9,173	ppm
Organic Nitrogen	24,606	ppm
Boron	157	ppm
Alkalinity as $CaCO_3$	93,240	ppm
pH	7.86	
Volatile Solids	6.49	%
Total Phosphorus as P	14,896	ppm
Total Solids in Sample	17.94	%
Volatile Solids in Sample	6.49	%

* On a dry weight basis

DANVILLE, VIRGINIA

The City of Danville, Virginia is a community of approximately 49,000 population located 50 miles north of Greensboro, North Carolina. The City's Southside Wastewater Pollution Control Facility consists of a secondary extended aeration process incorporating post-chlorination of the effluent. The settleable solids are thickened and placed in storage tanks, without stabilization, until the liquid sludge can be applied on nearby farmland.

Person Contacted

Mr. Jerry W. Harris
Assistant Chief of Operations
Water, Gas and Electric Departments
460 Williamson Road
Danville, Virginia 24541
Telephone: (804) 799-5153

Site Description

The City is presently utilizing 19 farms having a collective acreage of approximately 4,200 acres. Each site varies in size and cropping practice and is selected from a list of farmers requesting the addition of raw sludge to their land. Any farmer within a haul distance of 9 miles who desires to have sludge placed on his land may place a request with the City and if conditions are favorable (i.e., weather, season of the year, site accessibility, etc.), the sewage treatment plant will make one to four applications of sludge to his land per year. It is the policy of the treatment plant to spread sludge only on land which is not directly used to grow crops for human consumption. However, sludge has been applied to pasture land, fodder crops and tobacco.

General Information

The City estimated the industrial input to the Southside Wastewater Pollution Control Facility to be approximately 40 percent of the total flow. Industrial contribution to the sewage treatment plant is mainly from Goodyear Tire Company (the largest Goodyear plant in the U.S.), Porter-Disston tool, Dan River Mills (largest textile plant in the U.S.), and Corning Glass Company. Both Porter-Disston and Corning Glass pretreat their effluent. The population equivalent, based on 0.17 lbs BOD/cap/day is 63,870. The total amount of sludge leaving the wastewater treatment plant was 1490 dry tons in 1974 or 0.17 lbs/cap/day. This per capita figure is low because of the high industrial flow which is very low in solids. The overall treatment plant design capacity is rated at 15 MGD with an average daily flow of 10.5 MGD. The treatment plant is an activated sludge plant with two parallel aeration basins. Sludge from the clarifiers is piped to thickeners and stored in two unusable digesters until it is trucked to various farms in the area.

The secondary treatment facility was put on line in 1969. In 1973, construction began on a new secondary plant across the river from the existing plant, with a design capacity of 24 MGD. The new plant, which is scheduled for completion in 1976, will handle primarily the Dan River Mills' (textile) influent. The mill is presently discharging 60 percent of its waste in the Dan River. Following the completion of the new wastewater facility, sludge from the existing plant will be piped across the river to the new plant where it will be heat dried and hauled in dump trucks to farmland. This will be disced under upon application by the individual land owner.

There does not seem to be any problem with public acceptability of the sludge spreading practice. In fact, many farmers in Virginia and North Carolina within a radius of approximately 9 miles of the treatment plant have received and would like to continue receiving sludge. However, at the time of the visit, sludge was only being hauled to Virginia because the North Carolina State Public Health Service decided to further evaluate the effects of the raw sludge before approving further landspreading.

Sewage Sludge Composition

Analyses have been performed on the sludge by a private consulting firm (see Table 1).

Transport System

Currently, the City hauls all of the sludge to nearby farmland at 2.7 to 3.6 percent solids every week of the year. The City has been hauling liquid sludge for the past 13 years. The transport vehicles consist of 1974 deisel-tandem wheel Auto Car (4,600 gallons), purchased at a cost of $39,500 and a 1974 diesel-tandem wheel Auto Car (4,600 gallons), purchased at a cost of $45,000.

It was reported that an average of 14 loads per day is hauled from the plant. Two drivers and two vehicles are used essentially full time during the periods when sludge is hauled. The trucks are equipped with pumps and spreader devices and require approximately 10 minutes to load and 10 minutes to unload.

Landspreading System

The liquid sludge is spread by a pressure system from the side of the vehicles. Each load covers a different area depending on the vehicle: 1974 Auto Car, 1-1/2" discharge pipe which gives a 35 ft. spread of sludge, 1,800 gallons per acre, 500 lbs per acre dry weight at 3.5 percent solids; and, 1974 Auto Car, using a 1-1/4" pipe sprays approximately 50 ft., 1,800 gallons per acre, 500 lbs per acre dry weight at

3.5 percent solids. During wet weather periods when fields are unaccessible, the city spreads liquid sludge from the sides of the paved runway located at Danville's City Airport. The City makes four applications to each site. No problems of odors or flies were noted, even though the sludge is not always turned under immediately after application.

Cost

Based on actual operating information provided by the City of Danville, current cost for disposing of the City's sludge is $22 per dry ton. A more detailed cost analysis follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]			
1974 Auto Car Cost:	$39,500	$ 6,700	
1974 Auto Car Cost:	$45,000	$ 7,640	
Equipment Depreciation[2]			
Standing Pipe		20	
Total Annual Capital Cost			$14,360

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$3.25	60	$4,060
Driver	3.25	60	4,060
Lab Technician	4.11	5	430
Chief Operator	5.76	10	1,200
			$9,750

Fringe Benefits at 28 percent	$2,730	
Vehicle Maintenance and Operation (estimated)	$2,400	
Utilities		
Electricity at $100 per month	$1,200	
TOTAL ANNUAL OPERATING COST		$16,080
TOTAL ANNUAL CAPITAL AND OPERATING COST		$30,440
10% CONTINGENCY FACTOR[3]		$ 3,040
TOTAL ANNUAL COST		$33,480

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$33,480}{1,490 \text{ dry tons}} = \$22 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1000 per month.

[3] A 10% contingency factor is added to cover such items as administrative overhead.

Table I

Danville, Virginia Sludge
SCS Engineers, Consultant*

Parameter	PPM
Cadmium	29.7
Copper	247.0
Nickel	20.3
Lead	178.0
Zinc	350.0

*Analysis made on A.A.
Dry Weight Basis

FT. PIERCE, FLORIDA

Ft. Pierce, Florida, is a community of approximately 32,000 population located 70 miles due north of West Palm Beach. The City's wastewater treatment facility consists of a "standard" secondary activated sludge plant and a package secondary activated sludge plant (i.e., a small individual plant). Both plants stabilize the settleable solids by aerobic digestion, followed by post-chlorination of the effluent. Ultimately, the effluent is discharged into the Indian River, while the sludge is utilized on farmland.

Person Contacted

Mr. Richard Kasch
Wastewater Treatment Plant
Seaway Drive
Ft. Pierce, Florida 33450
Telephone: (305) 464-1996

Site Description

Of the total sludge generated, 95 percent is hauled in the liquid state to farmland owned by the Future Farmers of America (FFA) of Ft. Pierce, with the remainder being transported to other farms in the area. The FFA farmland, consisting of some 600 acres of available land for disposal of sludge, is fenced off into small parcels for the purpose of ongoing research. The terrain is flat--less than 1 percent slope--with a sandy-loam soil.

To obtain the City's remaining sludge, interested citizens contact the plant superintendent. When conditions are such that the driver is unable to traverse the FFA land (e.g., heavy rainfall periods, early spring, etc.), the City will haul sludge to other sites which are predominately used for grazing.

General Information

The City's superintendent of wastewater operations estimated the industrial input (from such contributors as citrus and tomato processors, a commercial laundry, and the seasonal tourist trade establishments) into the City's main facility and package plant to be approximately 10 percent of the total flow. The package plant receives 30 percent of the total influent and is equipped with a contact stabilization chamber, an aerobic digester, and a pre-chlorination tank. Although the average daily flow of the total system is 3.5 MGD, the overall treatment plant design capacity is rated at 5.0 MGD. The population served by the system is 32,000 with a population equivalent of 33,400 based on a BOD of 0.17 lbs/cap/day.

Although the average amount of sludge hauled from the main plant and the package plant on a daily basis equals approximately 10,000 gallons at 2.4 percent solids, seasonal variations are large. Sludge hauled from the plants in 1974-75 amounted to approximately 390 dry tons per year, or 0.07 lbs/cap/day. For the type of treatment employed, this figure is very low. This is apparently due to operational problems experienced by the plants.

Sewage Sludge Composition

No sludge analysis was available.

Transport System

Ft. Pierce hauls all of its digested sludge as a liquid at less than 3 percent solids and usually does so 52 weeks of the year. Transporting sludge by tank truck has taken place for the last 1 1/2 years, and the present transport vehicles include two 2,200-gallon tank trucks. One truck, a 1971 International, was purchased in 1971 at a cost of $8,790; the other vehicle, a 1974 International, was purchased at a cost of $9,820.

It was reported that an average of 35 loads of liquid sludge per week are hauled from the plant by two drivers. One driver works 90 percent of his time on sludge-hauling operations; and the other works during the peak tourist trade season (approximately 40 percent of the year). With a one-way haul distance of approximately 15 miles, the average round-trip driving time is 50 to 60 minutes. In addition, it takes approximately 10 minutes to load the sludge and 10 minutes to unload it at each site.

Landspreading System

Liquid sludge is applied by gravity flow directly from a pipe at the rear of the truck. A spreading device is not utilized on these trucks. Each load covers an area of 5,000 to 6,000 square feet (2,000 feet long x 2 1/2 to 3 feet wide). The application rate is approximately 2.4 dry tons of solids per acre per application. In instances in which two to three applications are made, as much as 5 to 7 1/2 tons of dry solids may be applied. Even though the sludge is never turned under after application, no problems of odors or flies have been noted.

Cost

Based on actual operating information provided by the City of Ft. Pierce, the current cost for disposing of its sludge is $81 per ton of dry solids. This high figure is primarily the result of a long haul distance and the $5,000 fee charged each year by the FFA for sludge disposal on its land. A more detailed cost analysis follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]		$ 3,160	
1971 International, Cost:	$8,790		
1974 International, Cost:	$9,800		
Total Annual Capital Cost			$ 3,160

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$3.18	90	5,950
Driver	$3.18	40	2,650
Lab Technician	$4.67	5	490
Superintendent	$6.72	5	700
Overtime			230
			$10,020

Fringe Benefits at 38 percent	$ 3,810
Vehicle Operation and Maintenance:	
Gasoline	1,980
Oil	70
Insurance	690
Truck License fees	10
Maintenance and Repair	4,370
	$ 5,120

TOTAL ANNUAL OPERATING COST	$20,950
TOTAL ANNUAL CAPITAL AND OPERATING COST	$24,110
10% CONTINGENCY FACTOR[2]	$ 2,411
COST FOR DISPOSAL ON FFA LAND	$ 5,000
TOTAL ANNUAL COST	$31,520

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$31,520}{390 \text{ dry tons}} = \$81 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

FRONT ROYAL, VIRGINIA

This community of approximately 9500 population is located 60 miles southwest of Washington, D.C. The City's sewage treatment facility consists of a primary plant incorporating post-chlorination of the effluent and anaerobic digestion of the sewage solids followed by air drying and/or direct application of liquid sludge to farmland adjacent to the treatment plant.

Person Contacted

Mr. C.H. Williams
Superintendent of Water and Wastewater
Box 1560
Front Royal, Virginia 22630
Telephone: (703) 635-3552

Site Description

Sewage sludge is applied primarily on 15 acres of City owned land. It is also applied to a large nearby farm when cropping conditions do not permit application to the City properly.

General Information

The treatment plant was constructed in 1950 and consists of primary treatment with a 1.5 MGD design capacity. The average daily flow is 1.2 MGD. Presently, the plant treats only domestic waste. (There is a large FMC plant in town but it does not discharge into the municipal system.) The City of Front Royal is reviewing plans for a new plant to be constructed in 1977 adjacent to the old plant. It intends to continue its landspreading operation and expects to purchase a new tank truck.

The sludge is anaerobically digested and thickened with enzymes and lime. The resulting solids content is reported to be approximately 15 percent. The City generates approximately 18,000 gallons of sludge per month, (i.e. 10-12 dry tons per month).

Sewage Sludge Composition

No sludge analysis was available.

Transport System

The City transports its sludge in a 1947 International truck equipped with a 1500 gallon tank. The vehicle was purchased in 1956 at a cost of $300. The haul distance from the loading area to the primary disposal site is approximately 1/4 of a mile. Because the vehicle is not operated on public roads, it is not maintained regularly, thereby reducing transportation costs.

Total loading and unloading time for the truck is 30 minutes. A truck driver is borrowed from the sanitation department on an average of one day per month for this operation. He applies approximately 12 loads of sludge (approximately 18,000 gallons) to the landspreading site. This is the total amount of sludge generated on a monthly basis. Sludge is stored in the digester between applications.

Landspreading System

Liquid Sludge - The sludge tank truck is equipped with a perforated "T" pipe at the rear of the tank to distribute the liquid sludge by gravity. In the field, the technique used to empty the load is to drive in low gear (10-15 mph) starting in the middle of the field making a continuous circle and proceeding until empty. The driver continues with this technique until the entire field is covered. A local farmer harvests hay from the 15 acre City property and discs the sludge under about once every three years. From two cuttings in 1974, the City field yielded 1,500 bales which is reported to exceed the yield of nonsludged fields in the area. No water, soil or plant monitoring system is provided at this site.

Drying Beds

Because of the proximity of the liquid disposal sites, the drying beds are only used when the digester needs repair. When the drying beds are used, the dried sludge is hauled away by local citizens.

Costs

Based on actual operating information provided by the City of Front Royal, the City is currently disposing of its liquid sludge at a cost of $5 per dry ton. A more detailed cost analysis follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost				
Vehicle Depreciation [1]			0	
1947, International Truck, Cost: $ 300				
Total Annual Capital Cost				0
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Driver	$3.73	5	$ 390	
Foreman	4.32	0.5	40	
Superintendent	5.78	0.5	60	
			$ 490	
Fringe Benefits at 25 percent				
Vehicle Operation and Maintenance				
Gasoline			$ 50	
Oil			10	
Antifreeze			10	
			70	
Utilities				
Electricity			10	
TOTAL ANNUAL OPERATING COST				$ 690
TOTAL ANNUAL OPERATING AND CAPITAL COST				$ 690
10 PERCENT CONTINGENCY FACTOR [2]				$ 70
TOTAL ANNUAL COST				$ 760

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$760}{\text{140 dry tons}} = \$5 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

GRAND RAPIDS, MICHIGAN

Grand Rapids is a fairly large metropolitan area with a wastewater treatment plant serving a population of 250,000. The plant currently vacuum filters approximately 65 percent of its sludge, most of which is incinerated. The remaining 35 percent is air dried and disposed of on nearby farmland. Both raw and waste activated sludge are processed at the facility.

Persons Contacted:

Mr. Otto Green
Superintendent of Wastewater Treatment
City of Grand Rapids
Wastewater Treatment Plant
1300 Market Avenue, S. W.
Grand Rapids, Michigan 49502
Telephone: (616) 456-3206

Mr. Jim Biener
Director of the Department of Environmental Protection
City of Grand Rapids
Wastewater Treatment Plant
1300 Market Avenue, S. W.
Grand Rapids, Michigan 49502
Telephone: (616) 456-3206

Site Description

All sludge from the vacuum filters or air drying beds that is not incinerated is hauled to one location and used either as a top dressing on completed portions of a sanitary landfill or spread on nearby farmland. The farm to which sludge is hauled is located about 10 miles from the treatment plant. The principal crop grown on the sludge amended soil is corn.

General Information

The wastewater treatment plant was built in 1929, and upgraded in 1954 to include two primary and four secondary digesters. Vacuum filters and an incinerator were added in 1959. The design capacity of the plant is 44 MGD with a current average daily flow of 47 MGD. Construction is presently underway to increase the overall capacity of the plant to 90 MGD. Plans call for the inclusion of the Zimpro heat treatment process and a general upgrading of the present incinerator.

It is estimated that 55 percent of the plant flow is from industrial or commercial establishments. There are 190 industries that contribute approximately 50,000 gal/day of a possibly toxic discharge. Grand Rapids also has one of the highest concentrations of metal plating industries in the U.S., although all of these plants are required to pretreat.

The plant is presently producing sludge at the rate of approximately 22 dry tons per day (i.e., 0.18 lbs/cap/day).

Sewage Sludge Composition

Table 1 presents data on the metals content of the sludge from the drying beds and the vacuum filters. The solids content of the sludge from the air drying beds is about 25 percent and that from the vacuum filters is 22 percent.

Transport System

The drying beds are only operated 12-15 weeks during the summer and handle about 30 percent of the sludge generated in the plant. The operation consists of one man who fills the beds for an estimated 480 hrs/year at $5 per hour and one man who cleans the beds at an estimated 500 hrs/year at $5.58 per hour. The front end loader used in cleaning the beds is rented at a rate of $6.22/hr. This includes the cost of fuel and maintenance for the 500 hrs/year it is in use. The sludge is loaded into one of several 20 yd^3 containers owned and maintained by a contractor who hauls the sludge away at a cost of $54.40 per load. Out of this, the contractor pays the farmer $12/load to dump the sludge in a pile on the farmer's land.

Most of the vacuum filtered sludge is incinerated. However, during times when the incinerator is not in operation, some digested vacuum filtered sludge is loaded by conveyor into one of the contractor's 20 yd^3 containers for transfer to the farmer's land. In FY 1975, 6 percent of the vacuum filtered sludge, or approximately 320 dry tons were handled in this manner.

Landspreading System

Since the farmer also operates a large sanitary landfill, he has considerable heavy equipment at his disposal for applying and incorporating the sludge into the soil. After the sludge has been stockpiled for several months, he utilizes a large scraper to spread the sludge at a depth of about two feet. This is then plowed into the soil with the aid of a crawler tractor. The farmer feels that this heavy earth-moving equipment is the only way to efficiently apply dried sludge to the land. During the 1974-1975 year, the farmer applied all of the sludge which he received onto a 23 acre plot of land. This amounted to over 143 dry tons per acre. To date, only one application has been made to any one field. However, at this heavy application rate the farmer has noticed some spots where nothing will grow within the first year after he has applied the sludge. These areas amounted to about 5 percent of the total field. Although the farmer did not have accurate records on crop yield, he stated that yields did increase significantly on the sludge amended soil the second year after it was applied.

Cost

Based on actual operating information provided by the City of Grand Rapids, the City is presently disposing of sludge from its drying beds at $15 per dry ton and from its vacuum filters at $54 per dry ton. On the vacuum filter operation, half of the cost of the building was applied to the filter operation and depreciated at 8 percent over 20 years. The vacuum filters were depreciated at 8 percent over 10 years. Because only 6.5 percent of the vacuum filtered sludge is landspread (the remainder is incinerated), only this portion of all vacuum filtering costs are included in this analysis. With the drying bed operation, dewatering accounted for $7 per dry ton while for the vacuum filter operation dewatering accounted for $48 per dry ton. A more detailed cost breakdown of capital and operating costs for each system follows. No reliable cost information was obtained regarding the sludge incineration operation.

COST FOR DISPOSAL OF AIR DRIED SLUDGE

Annual Capital Cost				
Vehicle Depreciation			0	
Equipment Depreciation			0	
Total Annual Capital Cost				0
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Laborer	$5.00	23	$2,390	
Front End Loader	$5.58	24	$2,790	
Administration				
Trucking			$3,200	
Sludge Conditioning			$ 360	
Sludge Storage & Pumping			$4,200	
			$12,940	
Fringe Benefits at 40 percent			$ 5,180	
Vehicle Maintenance and Operation				
Loader Rental			$ 3,110	
Contract Hauling			$15,380	
Pumping and Storage			$ 4,200	
TOTAL ANNUAL OPERATING COST				$40,810
TOTAL ANNUAL CAPITAL AND OPERATING COST				$40,810
10% CONTINGENCY FACTOR [1]				$ 4,080
TOTAL ANNUAL COST				$44,890

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$44,890}{2930 \text{ dry tons}} = \$15 \text{ per dry ton}$$

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[1] A 10% contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost				
Vehicle Depreciation			0	
Equipment Depreciation [1] 1960 Vacuum filter, cost -$81,600			770	
Building Depreciation [2] 1960 Building, cost - $262,600			$ 1,710	
Total Annual Capital Cost				$ 2,480
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Operators	$ 6.01	19	$ 2,370	
Supervision			360	
			$ 2,730	
Fringe Benefits at 40 percent			$ 1,090	
Vehicle Maintenance and Operation				
Contract Hauling			$ 1,710	
Vacuum Filter Maintenance and Operation				
Chemicals			$ 3,280	
Repairs			$ 3,820	
Utilities				
Electricity			$ 560	
TOTAL ANNUAL OPERATING COST				$13,190
TOTAL ANNUAL CAPITAL AND OPERATING COST				$15,670

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[1] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

[2] Buildings were depreciated over 20 years at 8% interest which amounts to a depreciation charge of $8.36 per $1,000 per month.

10% CONTINGENCY FACTOR [3]	$ 1,570
TOTAL ANNUAL COST	$17,340

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$17,340}{320 \text{ dry tons}} = \$54 \text{ per dry ton}$$

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[3] A 10% contingency factor is added to cover such items as administrative overhead.

Table I

METAL ANALYSIS - SLUDGE*

		Drying Beds	Filter cake
1975			
Jan.	Chrome	6300 ppm	3200 ppm
		4100 "	1600 "
Feb.		5000	2300
		4700	2700
		5100	2600
Jan.	Copper	8500 ppm	3800 ppm
		5800 "	2200 "
Feb.		8000	3500
		6300	2900
		7400	3200
Jan.	Nickel	3600 ppm	3600 ppm
		2300 "	800 "
Feb.		2300	1300
		2400	1500
		2900	1700
Jan.	Zinc	10100 ppm	5700 ppm
		7600 "	3400 "
Feb.		9000	4700
		8800	5600
		9000	4800
Jan.	Iron	21000 ppm	36000 ppm
		16000 "	24000 "
Feb.		17000	30000
		25000	28000
		19000	22000

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* All analyses are reported on a dry weight basis.

GREELEY, COLORADO

The City of Greeley, Colorado is a small community of approximately 55,000 population, located approximately 50 miles northeast of Denver. The City's sewage treatment operation consists of two separate wastewater treatment systems separated by the Cache La Poudre River. The North plant, which treats approximately two-thirds of the influent, is an activated sludge plant. The south plant uses trickling filters. The sludge produced by both plants is mixed just prior to digestion. Depending upon weather conditions and land availability, it is either liquid hauled to farm land or air dried. The effluent from both plants receives chlorination before release to the river.

Persons Contacted

Mr. Wyatt Sellers Plant Superintendent Greeley Wastewater Treatment Plant Greeley, Colorado	Mr. Gary Harkey Water and Sewer Department City of Greeley Greeley, Colorado

Site Description

Liquid Sludge Disposal - The City hauls liquid sludge to farm sites located approximately 4 to 7 miles from the treatment plant. Selection of the sites was on a first come, first served basis. At the time of the visit (October 1975), the City was hauling sludge to six sites and had a backlog of additional farmers requesting sludge. City policy limited sludge application at any given site to 10 dry tons/acre.

Air Dried Sludge - The City's air dried sludge is stored in an area adjacent to the sand drying beds that is accessible to the public. No regulations or other controls are placed upon the use or amount of sludge an individual may take.

General Information

The industrial contribution to the treatment plant is equal to approximately 2 percent of the total flow. Beatrice Foods (dairy) and the Greeley Meat Company are the two major dischargers to the City's treatment plant. The population equivalent, based on a BOD of 0.17 lbs. BOD/cap/day, is calculated to be approximately 58,000. The overall treatment plant design capacity is rated at 8 MGD. Currently, the average flow is 6.5 MGD.

The combined quantity of primary and secondary activated sludge generated totals approximately 39,000 gallons/day @ 2% solids (i.e., .3 dry tons/day). The concentration of solids in the sludge is somewhat lower than expected due to antiquated equipment and operational problems.

Transport System

Liquid Sludge - In 1974, the City liquid hauled approximately 60 percent of its sludge. The decision to air dry or liquid haul is dependent on the weather, the crop growing season and site availability. In general, the City is able to haul liquid sludge 6 to 8 months of the year. During the remaining months, the sludge is stored in the digesters or dried on sand beds.

The transport vehicle is an 8 year old 5,500 gallon tractor trailor which the City purchased for $9,200 in 1974. The tank is filled by gravity flow from the digesters. Since it takes approximately 40 minutes to load the vehicle (150 gpm), 20 minutes to drive the 10 miles round trip, and 20 minutes to offload, the vehicle is limited to an average of six or seven trips a day. The City has recently installed a pump on the gravity line, which cuts filling time to 15 minutes.

Air Dried - Since most of the air dried sludge is removed by citizens, the City rarely has to haul away any sludge. In 1974, the beds were filled 5 times for a total of 500 dry tons. During 1975 the decision was made to haul liquid sludge to the agricultural lands as much as possible. Therefore, the sand drying beds were utilized only once during this period.

Landspreading System

Liquid Sludge - The liquid sludge is applied by gravity flow directly from the rear of the truck through a spreading T. The farm to which sludge was being applied at the time of the site visit had received approximately 152 loads of sludge averaging 3% solids (105 dry tons). Sludge was placed upon approximately 45 acres of the farm at a rate of 2.3 dry tons/acre. Additional sludge will be hauled to the site weather permitting. As a general rule, an average of 2 dry tons are applied per acre. However, up to 10 dry tons have been applied per acre. (Precise records of the quantity, moisture content and application rates were only recently started).

Cost

The City currently employs 11 full-time employees and 7 seasonal employees at the treatment plant. The total operating budget for 1975 amounted to $242,662. Salaries and wages accounted for over 58 percent of the annual operating cost.

Based on the information provided by the City of Greeley, it appears that the City is currently disposing of its liquid sludge at a cost of $22 per dry ton while the cost for dewatering sludge on sand drying beds is $8 per dry ton. A more detailed breakdown follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost				$ 0
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Driver	$3.73	90	$6,980	
Supervisor	$6.90	10	1,440	
Total Personnel Cost			$8,420	
Fringe Benefits at 17 percent			$1,430	
Vehicle Maintenance and Operation				
Fuel			$ 560	
Tractor-Trailer Rental			$3,600	
TOTAL ANNUAL OPERATING COST				$14,010
TOTAL ANNUAL CAPITAL AND OPERATING COST				$14,010
10% CONTINGENCY FACTOR[1]				$ 1,400
TOTAL ANNUAL COST				$15,410

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$15{,}410}{700 \text{ dry tons}} = \$22 \text{ per dry ton}$$

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[1] A 10% contingency factor was included to cover such items as administrative overhead.

COST FOR DISPOSAL OF AIR DRIED SLUDGE

Annual Capital Cost				$ 0
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Operator	$4.23	15	$1,350	
Laborer	3.04	12	730	
Supervisor	7.16	1	140	
Total Personnel Cost			$2,220	
Fringe Benefits at 17 percent			$ 380	
Vehicle Maintenance and Operation (Front end loader with blade)				
Fuel			$ 360	
Rental			$ 560	
TOTAL ANNUAL OPERATING COST				$3,520
TOTAL ANNUAL CAPITAL AND OPERATING COST				$3,520
10% CONTINGENCY FACTOR[1]				$ 350
TOTAL ANNUAL COST				$3,870

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$3,870}{500 \text{ dry tons}} = \$8 \text{ per dry ton}$$

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[1] A 10% contingency factor is added to cover such items as administrative overhead.

BEAVERCREEK TOWNSHIP, GREENE COUNTY, OHIO

Beavercreek Township, Ohio is a predominately rural area between Xenia and Dayton, Ohio. The wastewater treatment facility, which is operated by Greene County, provides tertiary treatment consisting of an activated sludge process, secondary clarification, and microstrainers. Sodium aluminate is added to remove phosphorus and improve settling characteristics. The plant effluent receives post-chlorination before being discharged into Beaver Creek, which drains into the Little Miami River. All sludge receives secondary aerobic digestion before being applied to farmland.

Person Contacted

Mr. Charles Lenhart
Superintendent of Wastewater Treatment
Greene Co. Department of Sanitary Engineering
651 Dayton-Xenia Road
Xenia, Ohio 43585
Telephone: (513) 426-4540

Site Description

At the time of the site visit, the County was hauling liquid sludge to about 14 different site locations. These sites ranged in size from 13 to over 700 acres. The largest site was a sod farm, while corn, alfalfa, and beans were the major crops grown on the other farms. The County hauled sludge and applied it to the fields at no charge to the farmers. However, they preferred not to haul over five miles. Shortly after the beginning of 1976, the County modified its operation and now principally hauls sludge to the sod farm which is located four miles from the treatment plant.

General Information

The County estimates the industrial input into the Beavercreek Plant to be about 1 or 2 percent of the total flow. The major industrial sources are a meat processing plant which has pretreatment, custom laboratories, and an aircraft fuel systems manufacturing plant. The treatment plant serves a population of 23,000 and a population equivalent of 20,306 based on suspended solids, and a population equivalent of 25,103 based on BOD load. The plant was built in 1965 and expanded in 1972. The design capacity is 2.5 MGD with a design BOD population equivalent of 25,000. The average daily flow is 2.618 MGD. The treatment plant with all equipment on line will normally operate at 98 percent efficiency in the reduction of BOD and 95 percent reduction for suspended solids.

All sludge leaving the plant receives secondary aerobic digestion. This amounts to an average of 345,500 gallons per month at 2.2 percent solids, or about 380 dry tons per year. This represents a solids loading of 0.09 lbs/cap/day. While this figure tends to be high, it can be explained by the type of treatment process in use at the plant.

When the plant was expanded in 1972, two vertical basket centrifuges were installed but never operated. Plans are to place them into operation to thicken waste activated sludge from 1 percent to 5 percent before it goes to the digesters.

Sewage Sludge Composition

Table 1 shows data which was provided by the County on the composition of the sludge.

Transport System

The County owns a 6,000 gallon tank trailer with a diesel tractor for hauling sludge. When sludge is hauled, an average of 5 to 6 loads are hauled per day. The trailer is equipped with a 6-inch valve and splash plate. Before the County started hauling exclusively to the sod farm, sludge was applied by driving across the field or from the side of a road with the aid of hoses. In driving across open fields, the splash plate was used to unload the truck by gravity flow. This would provide a 12 to 14 foot wide coverage. When fields were too wet or crops were on the fields, the truck would be parked on a roadside adjacent to the field and varying lengths of six-inch collapsable hose were unloaded from the truck and carried out into the field. The sludge would then be allowed to run down crop rows or to spread out on hay land which often resulted in heavy but uneven applications. The average time for a 10-mile round trip haul is 25 minutes to unload with the splash plate or 35 minutes to unload with the hose. The trailer was purchased in 1972 and the tractor in 1975 for a total cost of $36,461.

In addition to the trailer tank truck, the county also owns a 1966 1,500 gallon tanker which is loaned to farmers if they wish to haul their own sludge. Less than 5 percent of the sludge is hauled by this truck.

Landspreading System

The liquid sludge is applied by gravity flow directly from the rear of the truck or by hose. A common application rate is two 6,000 gallons/acre or one dry ton per acre. Depending upon the crop grown, one or more applications will be made to a field each year with a maximum of about nine. One farmer who was interviewed claims a 330 percent increase in hay yield for land receiving heavy sludge applications as compared to that which did not receive any sludge. On alfalfa fields, sludge will be applied immediately after each cutting and possibly after the alfalfa has started to grow back. On row cropped land, sludge is applied both while the field is dormant, as well as when crops are on the field, by running sludge down the rows by gravity flow.

After the County decided to haul all the sludge to the sod farm, the farmer purchased 4-inch irrigation pipe, a farm tractor p.t.o. driven sludge pump, and a big gun nozzle. With this system, the 6,000 gallon tanker is unloaded from the road in 15 minutes. With a 1.4 inch nozzle and 85 psi., each load will apply 0.2 inches of sludge to 1.13 acres, i.e., a radius of 125 feet. Cost of spray irrigation equipment was $7,000.

Cost

Based on information provided by the County, the cost for sludge disposal from the Beavercreek Township Plant is $40 per dry ton. This cost may be slightly higher than for other plants because of the small-scale operation, low percentage of solids in the sludge and the high depreciation costs on the new transport vehicle. A detailed cost breakdown follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1] 1975, International Tank/Trailer, Cost: $36,500	$ 6,190	
Stationary Equipment Depreciation[2] (Heater and Standing Pipe)	140	
Total Annual Capital Cost		$ 6,330

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$5.00	38	$3,960
Superintendent	$8.00	6	990
			$4,950

Fringe Benefits at 20 percent	$ 990	
Vehicle Operation and Maintenance		
Operation Costs	$1,290	
Maintenance and Repair Costs	$ 160	
	$1,450	
TOTAL ANNUAL OPERATING COST		$ 7,390
TOTAL ANNUAL CAPITAL AND OPERATING COST		$13,720
10 PERCENT CONTINGENCY FACTOR[3]		$ 1,370
TOTAL ANNUAL COST		$15,090

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$15{,}090}{380 \text{ dry tons}} = \$40 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

[3] A 10% contingency factor is added to cover such items as administrative overhead.

Table 1

Analytical Data Generated by the Beavercreek Wastewater Treatment Plant Lab on Composite Samples of Secondary Digested Sludge -- Sample Period August 1 - August 19, 1975

Total Solids - Dry	2.2%
Volatile	54%
Suspended Solids	17,290 mg/l
Volatile	9,520 mg/l
PH	6.9
BOD	2,160
Nitrogen	3.25%
Phosphorus as P_2O_5	7.32%
Potassium as K_2O	1.58%
Cd	9 mg/l
Cr	39 mg/l
Cu	568 mg/l
Pb	134 mg/l
Hg	0 mg/l
Ni	28 mg/l
Zn	1,734 mg/l

LaCROSSE, WISCONSIN

The City of LaCrosse, Wisconsin, has a population of approximately 65,000 and is located 120 miles northwest of Madison. The City's wastewater treatment plant consists of a secondary activated sludge system which incorporates post-chlorination of the effluent and anaerobic digestion of the settleable solids. Following digestion, the solids are vacuum filtered and/or applied directly to nearby farmland. The effluent is discharged directly into the Mississippi River.

Person Contacted

Mr. Grant Haugstad
Superintendent of LaCrosse
Wastewater Treatment Plant
LaCrosse, Wisconsin
Telephone: (608) 784-4882

Site Description

Presently, the City hauls liquid and vacuum-filtered sludge to several small farms that vary in size and cropping practice. Any citizen with land within a radius of 10 miles and east of the Mississippi River who desires to receive sludge may place a request with the Superintendent of the LaCrosse Wastewater Treatment Plant. If conditions are favorable (e.g., groundwater table, soil types, runoff, weather, site accessability, etc.), the wastewater treatment plant will apply sludge to the property one or more times during the year.

General Information

Industrial contribution to the wastewater treatment facility is approximately 50 percent of the total flow. Based on a BOD of 0.17 lbs. per cap per day, the population equivalent is approximately 140,000. The design capacity of the system is 22 MGD with an average daily flow of 13.9 MGD.

The combined quantity of primary, secondary-clarified and activated sludge is approximately 190,000 gallons per day at 2.5 percent solids prior to digestion. Following digestion this equals 0.54 lbs. of solids per capita per day (i.e., 4360 dry tons per year) which is a high generation rate. This high solids loading can be partially explained by the local brewery which discharges a high solids effluent.

LaCrosse started disposing of its liquid sludge on agricultural land in 1973. The quantity of sludge increased significantly with the addition of an activated sludge system. In 1974, a dewatering system consisting of two vacuum filters was incorporated into the treatment plant. Following the installation of the filters, the City purchased their first dry sludge spreader and began applying digested sludge in cake form to nearby agricultural land.

Full-scale operation of present land utilization practices began in April, 1975, with the acquisition of a second cake spreader and a second liquid tank truck. The City has ordered a third cake spreader (12-yard capacity) to be in service by March 1976.

Sewage Sludge Composition

Table 1 presents data relative to the metal content of LaCrosse sludge. Analyzed at the University of Wisconsin for several elements, the sludge was shown to be fairly low in metals, except Fe (21,000 ppm). This particular element has a higher concentration mainly because the following industries discharge their wastes without any form of pretreatment: a manufacturer of heating and air conditioning parts, a lamination plant, a machine shop, a brewery, and several bottling firms and laundromats.

Transport System

Liquid Sludge - The City liquid hauls about 15 percent of its sludge. The decision to liquid haul or to vacuum filter the sludge is solely determined by the storage capacity of the digesters and the type of sludge desired by the farmer. In general, the City liquid hauls an average of 10 to 15 loads of sludge per day at 3 percent solids 40 to 45 weeks of the year. The vehicle used in transporting liquid sludge is a 3,500 gallon tank truck purchased in 1975 at a cost of $14,000. Two drivers are used full time to provide a two shift operation during periods when sludge is liquid hauled (i.e., early Spring and late Fall). The average haul distance is approximately eight miles one way, with an average round-trip driving time of 40 minutes. The time required to load as well as unload the truck is approximately seven minutes.

Vacuum Filtered Sludge- The transport system used in hauling the filtered sludge includes a 1974 seven yard Ford Knight Spreader, purchased at a cost of $10,900, and a 1975, 12-yard International Knight Spreader, purchased at a cost of $19,000. Hauling time for the dry sludge is the same as the wet, with a 30 minute loading time for the seven yard truck and a 45 minute loading time for the 12 yard truck. An unloading time of 10 minutes is required for both trucks.

The vacuum filters were purchased in 1972 and 1974 at a cost of $120,000. They are operated 16 hours a day, 5 days a week with a total of 8 operators for the two shift operation. The solids content after dewatering is 25 percent.

Landspreading System

Liquid Sludge - The liquid sludge is applied by gravity flow from the distribution "T" located at the rear of the vehicle. Each load covers an area of 15,000 square feet (i.e., 1500 feet long by 10 feet wide). It is calculated that approximately 1.3 dry tons are applied per acre per application. No recent problems with odors or flies were noted, even though the sludge is not always turned under immediately after being applied. The farmer usually turns the sludge into the soil after the field has been fully covered.

The City has been and is currently hauling most of its sludge to soybean, oats, rye, and corn fields. Applications are only made after the field is cropped or before the spring planting. With the high cost of inorganic fertilizers, this has made the use of organic fertilizers (i.e., sludge) even more popular with local farmers in the community.

Vacuum Filtered Sludge - The dried filter cake is applied by a Knight Spreader dump truck. This vehicle is equipped with a chain conveyer which moves the dry cake to the rear of the truck where a grinding mechanism breaks the cake into fine particles and evenly distributes the material.

Cost

The City currently has 30 employees at the wastewater treatment plant. Half of the personnel are involved in some aspect of disposal of digested sewage sludge.

Based on actual operating information provided by the City of LaCrosse, the 1974 cost for liquid sludge disposal was $49 per dry ton while for vacuum-filtered sludge, the cost amounted to $81 per dry ton. For the vacuum-filtered sludge, the cost of dewatering accounts for $68 per dry ton. The major cost items in the dewatering process are personnel costs of approximately $110,000 and chemical costs of approximately $70,000. A more detailed cost analysis of each system is presented on the following pages.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1] 1975-Ford Tank Truck, cost-$14,000	$ 2,380	
Equipment Depreciation [2] Standing Pipe, cost-$50	10	
Total Annual Capital Cost		$ 2,390

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
2 Truck Drivers	$4.60	100	$19,140
Chemist	4.95	3	310
Chemist Assistant	4.25	3	260
Superintendent	6.90	3	430
			$20,140

Fringe Benefits at 38 percent	$ 7,650	
Vehicle Operation and Maintenance		
Parts	$ 600	
Fuel and Oil	940	
Insurance, Fees and Tags	90	
TOTAL ANNUAL OPERATING COST		$29,420
TOTAL ANNUAL CAPITAL AND OPERATING COST		$31,810
10% CONTINGENCY FACTOR [3]		$ 3,180
TOTAL ANNUAL COST		$34,990

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$34{,}990}{710 \text{ dry tons}} = \$49 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of 12.13 per $1000 per month.

[3] A 10% contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$ 5,090	
1974 Ford Knight Spreader, cost-$10,900		
1975 Int. Knight Spreader, cost-$19,000		
Equipment Depreciation [2]	$17,470	
2 vacuum filters, cost-$120,000		
Total Annual Capital Cost		$ 22,560

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
8 vacuum filter operators	$4.60	100	$76,540
2 Truck drivers	4.60	100	19,140
Chemist	4.95	17	1,730
Chemist Assistant	4.25	17	1,480
Superintendent	6.90	17	2,410
			$101,300

Fringe Benefits at 38 percent	$ 38,500	
Vehicle Operation and Maintenance		
Parts	$ 3,400	
Fuel and Oil	4,950	
Insurance, Fees and Tags	200	
Vacuum Filter Maintenance		
Chemicals	$ 70,000	
Parts and repairs	15,000	
Utilities	$ 11,920	
TOTAL ANNUAL OPERATING COST		$245,270
TOTAL ANNUAL CAPITAL AND OPERATING COST		$267,830

---

[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1000 per month.

10% CONTINGENCY FACTOR [3]	$ 26,780
TOTAL ANNUAL COST	$294,610

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$294{,}610}{3650 \text{ dry tons}} = \$81/\text{dry ton}$$

---

[3] A 10% contingency factor is added to cover such items as administrative overhead.

Table 1

LaCrosse Sludge Analysis*
January, 1974

N	2.06%
P	2.79%
K	3.53%
Ca	20.6 %
Mg	0.60%
Na	0.70%
Al	264 ppm
Fe	21,100 ppm
B	159 ppm
Cu	343 ppm
Zn	580 ppm
Mn	309 ppm
Cr	314 ppm
Ba	342 ppm
Sr	121 ppm
Dry Matter	26 %

* Chemical laboratory results are all on a Dry Matter basis.

LAWRENCEVILLE, ILLINOIS

The community of Lawrenceville, Illinois, is located 70 miles due north of Terra Haute, Indiana and has a population of 5,800. The community's wastewater treatment plant is a primary treatment-clarification system whose effluent is discharged into the Wabash River. The settleable solids are pumped into a sludge holding tank for storage. At the end of each week, the sludge is pumped to a vacuum filter for dewatering prior to being hauled to agricultural land.

Persons Contacted

Mr. Bill Goff
Superintendent of the Wastewater
Treatment Plant
Lawrenceville, Illinois 62439

Mr. Francis Perkins
Mayor of Lawrenceville
Lawrenceville, Illinois 62439
Telephone: (618) 943-4115

Site Description

Lawrenceville transports its vacuum-filtered sludge to a 100-acre farm that is located approximately 8 miles west of the wastewater treatment plant. The soil on the site is a clay-loam. The farmer plans to plant the sludge treated land in soybeans and corn in 1976. In the past farmers have observed improved crop response on sludge treated soils. However, no yield measurements were available.

General Information

The wastewater treatment facility was constructed in 1961 with a design capacity of 2.0 MGD. The average daily flow through the treatment plant is only 0.5 MGD due mainly to the fact that the various industries within the area presently treat their own wastes. The reasons for the unusual handling of industrial wastes are the stringent regulatory controls within the state of Illinois concerning industrial discharges and the fact that Texaco, whose refinery contributes 95 percent of the total industrial activity in Lawrenceville, is trying to generate a favorable working relationship with the town by treating its own wastes.

Settleable solids from the clarifier are pumped into a sludge holding tank without any stabilization. Based on records from the wastewater treatment plant, the total amount of sludge filtered in 1975 was approximately 70 dry tons, which amount to 0.06 lbs of solids per capita per day. This figure is about half of what it should be for the type of treatment employed and can only be explained by the fact that there is no industrial contribution.

The undigested sludge that comes off the vacuum filter at 18 percent solids is hauled to the utilization site.

Sewage Sludge Composition

No sludge analysis was available.

Transport System

The community utilizes a Ford 2-ton dump truck to dispose of its dewatered sludge. This vehicle was purchased new in 1970 at a cost of $5,200.

The sludge is hauled once every week (usually on Friday) by a laborer who also operates the vacuum filter. The complete process is an 8-hour job, with loading of the truck taking 5 hours. The site where the sludge is currently disposed of is located 8 miles from the plant. It requires a total of 30 minutes of driving and an additional 5 minutes to unload.

Landspreading System

The City stockpiles the sludge on the land and it is the farmer's responsibility to spread and turn the sludge under as soon as possible after application in order to prevent problems from odors.

Cost

The City currently employs 4 full-time personnel at its treatment plant. The operating budget for Fiscal Year 1975 was $44,850.87, of which salaries accounted for 40 percent.

Based on actual operating information provided by the City of Lawrenceville, the City is currently disposing of its vacuum filter sludge at a cost of $190 per ton. Of this, the cost of dewatering accounts for approximately $120 per dry ton. Dewatering costs are high due to the low quantity of sludge produced and the high chemical costs. A more detailed cost breakdown of the capital and operating costs is presented on the following page.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]			$ 880	
1970 Ford Dump Truck, Cost-$5,200				
Stationary Equipment Depreciation			0	
Building Depreciation			0	
Total Annual Capital Cost				$ 880

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
Laborer	$3.42	20	$1,420	
Superintendent	7.70	7.5	1,200	
			$2,620	
Fringe Benefits at 44 percent			$ 870	
Vehicle Maintenance and Operation				
Repairs			$ 0	
Fuel and Oil			30	
Insurance			180	
Utilities			$2,130	
Vacuum Filter Maintenance				
Chemicals			$5,430	
Parts and Repair			0	
TOTAL ANNUAL OPERATING COST				$11,260
TOTAL ANNUAL CAPITAL AND OPERATING COST				$12,140
10% CONTINGENCY FACTOR [2]				$ 1,210
TOTAL ANNUAL COST				$13,350

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$13,350}{\text{70 Dry Tons}} = \$190/\text{dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8 % interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

LEBANON, PENNSYLVANIA

The City of Lebanon, Pennsylvania is a community of approximately 28,000 population which is located 70 miles northwest of Philadelphia. The City's sewage treatment facility consists of a secondary extended aeration plant incorporating post chlorination of the effluent and anaerobic digestion of sewage solids, followed by direct application of liquid sludge to local farmland.

Person Contacted

Mr. Bob Kline
Superintendent, Lebanon Sewage
Treatment Plant
Lebanon, Pennsylvania
Telephone: (717) 272-2841

Site Description

Only one land application site is used. It is located approximately five miles southwest of the sewage treatment plant. The soil is Duffield/ Hagerstorm loam-limestone.

General Information

The plant was constructed in 1962 with a design capacity of 6.5 MGD. The average daily flow is 4.0 MGD. The industrial input into the City's treatment facility is estimated to be 25 percent of the total flow, with a population equivalent of approximately 45,000. The sludge is anaerobically digested with a solids content of 4 percent. It is stored in a secondary digester until an appropriate time is selected to apply the sludge to nearby farm land.

The total sludge after digestion leaving the plant and applied to farm land averages 1,055,900 gals/year at 4 percent solids (i.e., 180 dry tons of solids per year). This calculates to 0.035 lbs/cap/day. This generation rate appears to be low. One explanation for this may be that sludge records are kept on the number of loads each week and not the total gallons. Two different capacity tank trucks are used by the wastewater treatment plant to transport liquid sewage sludge. This makes record keeping difficult, as it does not indicate exactly how many loads each truck hauls. When the plant was built, a coil vacuum filter was included in the total facility design as the method of dewatering. The filter was in operation until 1966. At that time the relative economics of the vacuum filter operation were assessed and it was determined that landspreading of liquid sludge would be more cost-effective. The City then began hauling liquid sludge to a local landfill until the State of Pennsylvania prohibited the disposal of sewage sludge in landfills.

Liquid sludge is now used on agricultural lands. This practice has resulted in a limited number of complaints concerning odors which were registered from residents near the application fields. It is assumed that the complaints have resulted from applying liquid sludge near residences without discing the sludge under.

Lebanon is considering upgrading its facilities in the future, although the method of sludge disposal is expected to remain the same.

Sewage Sludge Composition

No analysis of the sludge was available.

Transport System

Currently, all digested liquid sludge is hauled to a farm approximately five miles from the treatment plant in a 1962 International 2,000 gallon tank truck and a 1963 Diamond "T" 1,600 gallon tank truck. The liquid sludge flows by gravity from the digester to the liquid tank trucks. From the plant, the sludge is hauled to a 100 acre farm plot. The time involved in the total operation is 30 minutes round trip (i.e., 10 minutes to load, 15 minutes in traveling, and 5 minutes to unload the truck). The truck driver averages 600 loads per year with the tank trucks; of this, the Diamond "T" hauled approximately 200 loads while the remaining 400 loads are hauled by the International. The decision to haul on a particular day is solely based upon the availability of land, weather conditions, and the season of the year. In general, the City hauls most of its sludge during early spring and late fall, after the land has been fully or partially cropped. Corn is the principal crop to which sludge has been applied.

Landspreading System

The digested liquid sludge is applied to the land by a single pipe extended from the rear of each tank truck. The driver controls the application of sludge by opening and closing a valve located on the rear of the truck. Once the valve is open, the truck proceeds in a straight line in low gear (i.e., 10 to 15 mph) until the vehicle is empty. There is a heavier application at the start of the operation and a much lighter application at the end due to the method of spreading employed. The driver spends 14 percent of his working year hauling sludge to the land disposal site. Assuming 180 dry tons of sludge were applied per year to the 100 acre farm, approximately 1.8 dry tons/acre/year is disposed of on this land. The sludge is not immediately turned under by the farmer after application. According to the farmer, he has noticed a great increase in crop yields where sludge has been applied.

Cost

Utilizing actual operating cost information provided by the City of Lebanon, it appears the City is currently disposing of its sludge at a cost of $28 per ton of dry solids. A more detailed cost breakdown follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]		
1962, International, cost-in 1970-$1,300	$ 220	
Stationary Equipment Depreciation[2]		
Standing Pipe, cost-$500	70	
Total Capital Cost		$ 290

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$4.00	14	$1,160
Maintenance	5.02	1	10
Maintenance Assistant	4.13	1	10
Superintendent	6.50	0.5	70
			$1,250

Fringe Benefits at 20 percent	$ 250	
Vehicle Operation and Maintenance		
Repairs	$2,060	
Gasoline	430	
Oil	30	
Insurance and Fees	300	
	$2,820	
TOTAL ANNUAL OPERATING COST		$4,320
TOTAL ANNUAL CAPITAL AND OPERATING COST		$4,610
10% CONTINGENCY FACTOR[3]		$ 460
TOTAL ANNUAL COST		$5,070

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$5,070}{180 \text{ dry tons}} = \$28 \text{ per dry ton}$$

---

[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1000 per month.

[3] A 10% contingency factor was included to cover such items as administrative overhead.

LITTLETON, COLORADO

The City of Littleton, Colorado is a community of approximately 41,000 population located about 10 miles south of Denver, Colorado. The sewage treatment facility consists of a trickling filter and a Purox package plant. Sludges generated are anaerobically digested and dried on sand drying beds. The dried sludge is then used on City owned lands or sold to the general public for $2 per cubic yard.

Persons Contacted

Mr. David Godsey
Superintendent
Sewage Treatment Plant
Littleton, Colorado
Telephone: (303) 794-4214

Mr. Charlie Kerven
Assistant Superintendent
Sewage Treatment Plant
Littleton, Colorado
Telephone: (303) 794-4214

Site Description

The City's sand drying bed sludge is stockpiled for later use on City parks, flower beds, etc., or is sold to the general public at $2 per cubic yard. There are no controls on the usage of the digested air dried sludge on either the City or general public.

General Information

The treatment plant consists of two parts: a primary trickling filter plant with a design capacity of 4.5 MGD and a secondary Purox package plant with a design capacity of 1 MGD. The population equivalent, based on a BOD of 0.17 lbs/cap/day is 44,520. The average daily flow is 5 MGD. Because storm water is separate, daily flow rarely exceeds the current design capacity.

The City reported flow of primary and secondary sludge at 18,000 and 6,000 gallons per day respectively at approximately 2 percent solids. Based on these figures a combined sludge production was calculated to be 2 dry tons per day prior to digestion. It is assumed that the digestion in this case gives a reduction in total solids of approximately 30 percent. Therefore, total sludge production after digestion is estimated to be 1.4 dry tons per day (510 dry tons/year) or .07 lb/capita/day.

The City is presently constructing a new plant to be shared with another community. This should be on line by late 1977.

Sewage Sludge Composition

No sludge analysis was available.

Transport System

Sludge from the sand drying beds is stockpiled and removed mainly by private citizens. An unknown quantity is hauled in the City's dump trucks for use on City property.

Sand Drying Bed Operation

The ten sand drying beds occupy an area of approximately 1.5 acres. Each bed is emptied about four times a year. The sludge remains on the drying bed for approximately 8 to 10 weeks during the summer and 10 or more during the winter. Sludge removed from the drying beds during the winter months is stockpiled separately so that it may dry further before utilization. Cleaning the beds requires 16 man hours per bed, while loading requires 4 to 5 man hours.

Costs

Based on information provided by the City, the cost for disposal of the City's air dried sludge is $13 per dry ton. A more detailed cost analysis is attached.

COST FOR DISPOSAL OF AIR DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	0	
1964 Crawler Tractor, Cost: $2,700		
Equipment Depreciation[2]	$2,450	
Dry Beds		
Total Annual Capital Cost		$ 2,450

Annual Operating Cost

Personnel	Hourly Wage	% Time Worked	Cost
Operator	$4.50	19	$1,850
Operator	4.50	19	1,850
			$3,700

Fringe Benefits at 20 percent	$ 740	
Vehicle Maintenance and Operation		
Repairs	$ 220	
Fuel, oil	$ 160	
	$ 380	
Maintenance of Beds	$2,200	
TOTAL ANNUAL OPERATING COST		$ 7,020
TOTAL ANNUAL CAPITAL AND OPERATING COST		$ 9,470
10% CONTINGENCY FACTOR[3]		950
REVENUE (Sale of sludge at $2 per cubic yard)		$ 4,000
TOTAL ANNUAL COST		$ 6,420

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$6,420}{510 \text{ dry tons}} = \$13 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1000 per month.

[3] A 10% contingency factor is added to cover such items as administrative overhead.

LOUISVILLE, KENTUCKY

Louisville, Kentucky is located in north central Kentucky. The City provides primary treatment and serves a population of approximately 500,000. The design capacity is 100-105 MGD and the average daily flow is 90 MDG. Between 80 and 85 percent of the collection system is combined storm and sanitary sewers. The maximum storm flow capacity of the plant is 338 MGD.

Persons Contacted

Thomas McBride
Superintendent

Richard Hutchelson
Plant Manager

Dean Taylor
Consultant and Former Superintendent
Morris Foreman Treatment Plant
4522 Algonquin Parkway
Louisville, Kentucky 40211
Telephone: (502) 775-6481

Site Description

The City currently uses an eleven acre landfill site. Sewage sludge is the only material disposed of at this landfill.

General Information

At the time of our visit, a $66 million expansion of this plant was under construction and should be fully operational in early 1976. This expansion will provide secondary (activated sludge) treatment. The design capacity is 200 MGD. In the new system, the sludge will be vacuum filtered, oxidized (Zimpro), and incinerated (multiple hearth). The incinerators are equipped with waste heat boilers which will heat the solids handling building and the administration building. The settleables are currently anaerobically digested and vacuum filtered. The digested sludge is about 6.8 percent solids. This sludge is thickened to about 14 percent solids then vacuum filtered to about 29 percent solids. In fiscal year 1975, 15,900 tons of filter cake were produced representing 4590 tons of dry solids. About 50% of the flow and BOD load on this plant is from industrial sources.

Sewage Sludge Composition

The following heavy metals analysis has been performed on the sludge:

HEAVY METALS ANALYSIS-1974

Constituent	Concentration (ppm dry wt. basis)
Zn	4,486
Cr	2,128
Cd	186
Ni	883
Pb	2,066
Cu	1,272
Fe	18,386
Mn	303
Hg	0.34

Transport System

Sludge is hauled from the plant by three fifteen cubic yard dump trucks to the landfill site. The site is located approximately three miles from the plant and the average round trip time per load varies from 30 to 45 minutes. The dump trucks are loaded from an inclined belt conveyor running from the vacuum filters.

Landfill Operation

The sludge is dumped into piles at the landfill site. Three to four times per year a contractor is brought in to spread and cover the sludge. This operation requires two days on each occasion.

Some developers use the sludge as a substitute for top soil. Anyone can request the sludge and pick it up at the landfill. However, the plant personnel prefer that they are informed before large quantities of the sludge are taken.

Cost

Based on information provided by the City of Louisville, the City's cost for disposal of vacuum filtered sludge in fiscal year 1975 was $50 per dry ton. Of this, the cost of dewatering the sludge was about $33 per dry ton. Major costs for dewatering included personnel costs of about $49,000, vacuum filter maintenance of $26,000 and chemical costs of $26,000.

COST FOR DISPOSING OF VACUUM FILTERED SLUDGE

Personnel (includes fringe benefits)	$ 58,190	
2 Vacuum Filter Operators		
1 Laborer		
1 Truck Driver		
1 Supervisor		
Plant		
Depreciation of Vacuum Filters	18,080	
Maintenance of Vacuum Filters and Trucks	30,050	
Chemicals and Materials	25,940	
Utilities	20,000	
Transportation (includes capital cost for trucks)	55,990	
SUBTOTAL		$208,250
10 PERCENT CONTINGENCY FACTOR[1]		$ 20,820
TOTAL ANNUAL COST		$229,070

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$229,070}{4590 \text{ dry tons}} = \$50 \text{ per dry ton}$$

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[1] A 10% contingency factor is added to cover such items as administrative overhead.

MACON, GEORGIA

The City of Macon, Georgia is a community of approximately 100,000 population located 70 miles southeast of Atlanta, Georgia. The City's Lower Poplar Street sewage treatment facility consists of a secondary trickling filter plant incorporating pre-chlorination of the influent and anaerobic digestion of primary and secondary clarifier solids. The digested solids are dewatered on sand drying beds or applied directly to treatment plant land.

Person Contacted

Robert Moore
Superintendent of the Lower Poplar
Street Sewage Treatment Plant
780 Third Street
P. O. Box 108
Macon, Georgia 31202
Telephone: (912) 745-9411 ext. 282

Site Description

Liquid Sludge Disposal

City owned property adjacent to the treatment plant has been utilized for the past eight to ten years for the disposal of liquid sludge. This particular piece of property is utilized because hauling costs are minimal, it is always available for sludge disposal, and there are no residential dwellings adjacent to the property. The soil is of the Chewacla classification (a sandysilt to siltysand). No fertilizer other than sludge is used to produce the hay grown on the property.

Drying Bed Sludge Disposal

Sludge from the drying beds is made available for use by area residents. In 1973, many local farmers used the dried sludge for soil erosion control. However, in 1974 the drying beds were used to a very limited extent because the City preferred to liquid haul to their hayland. This resulted in increased hay revenue. Also the drying beds are old and very inefficient.

General Information

The sewage treatment plant is a primary clarification system followed by a trickling filter, secondary clarification and discharge. The sludge goes through both primary and secondary anaerobic digesters. The detention time is approximately three months with the solids content of the sludge estimated to be about four percent.

The plant superintendent estimates the industrial input into the Lower Poplar Street Plant to be about 30 percent of the total flow. Principal industrial contributors are a tannery, a poultry processor, an oil and soap manufacturing plant, a zipper manufacturer, and a textile dyeing operation. Treatment plant personnel estimated that the Lower Poplar Street Plant serves 60 percent of the residential community of Macon with the remainder flowing into the Rocky Creek Plant (with a 14 MGD capacity). Plans for a plant expansion are forecasted in three years due to the present overload on the system. The average daily flow through the plant is 12.8 MGD and the design capacity was 12 MGD. The effluent is discharged into the Ocmulgee River.

Sewage Sludge Composition

Table 1 presents data on the sludge analysis. Samples were taken from the #5 secondary digester on October 9, 1975 by SCS Engineers and analyzed for a comprehensive list of heavy metals. As is indicated, the sludge is fairly low in heavy metals.

Transport System

Liquid digested sludge is hauled at 4 percent solids content in a 1600 gallon tank mounted on a one and a half ton dump truck. Since sludge is only hauled about 40 days out of the year, the tank is removed during the remainder of the year to free the truck for maintenance work around the plant. Although sludge is hauled a relatively small number of days each year, the operation is spread out over a nine month period as shown in Table 2. On days that sludge is hauled, an average of 24 loads per day are removed. The average haul distance is about one mile with a round trip driving time of 15 minutes. Time required to load and unload the tank is about five minutes each.

Landspreading System

The liquid sludge is applied to the field by gravity flow from the rear of the truck. Two pipes, with hydraulic valves that are operated from inside the cab, discharge sludge onto a metal splash pan. Each tank load will cover an area of about 10 feet wide by 1000 feet long, which gives an application rate of about 1 dry ton per acre. During 1974, the application of sewage sludge applied on the City's property averaged 2 dry tons per acre. Sludge is applied to the hay field whenever the ground is sufficiently dry for the truck to operate and the hay is at a stage of growth which will not be hampered by an application of sludge. Because the sludge is being applied to an established hay field, the ground is not cultivated and therefore the sludge is not turned under. Even so, there were no apparent problems with odors or flies. At the time of the site visit there had been two cuttings of hay with a third cutting possible. The local farmer who bales the hay for the City pays 25¢ per bale which amounted to $1,650 for the two cuttings in 1974.

Costs

Based on actual operating information provided by the City of Macon, it appears the City is currently disposing of its digested sewage sludge at a cost of $8 per ton of dry solids. A more detailed breakdown of the capital and operating costs follows.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Stationary Equipment Depreciation[1] (Standing Pipe)	$ 40	
Total Annual Capital Cost		$ 40

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$2.40	14	$ 680
Office Manager	4.77	2	200
Superintendent	6.97	2	290
			$1,170

Fringe Benefits at 33 percent	$ 390	
Vehicle Operation and Maintenance:		
Gasoline	$ 180	
Oil and Lube	10	
Insurance	300	
Licenses	2	
Parts	330	
Labor for Repairs	290	
	$1,110	
TOTAL ANNUAL OPERATING COST		$2,670
TOTAL ANNUAL CAPITAL AND OPERATING COST		$2,710
10 PERCENT CONTINGENCY FACTOR[2]		$ 270
SUB TOTAL		$2,980
REVENUE (Sale of Hay)		$1,650
TOTAL ANNUAL COST		$1,330

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$1,330}{170 \text{ dry tons}} = \$8 \text{ per dry ton}$$

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[1] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

[2] A 10% contingency factor is added to cover such items as administrative overhead.

TABLE 1
MACON, GEORGIA
SLUDGE ANALYSIS
(Emission Spectrophotometry)

Element	PPM DRY Wt.
Si	190,755
Ca	11,304
Al	84,780
Fe	31,793
Mg	7,772
Ti	5,581
P	4,027
Ba	1,059
B	25
Pb	381
Sn	106
Mn	360
Cr	572
Ga	42
Cu	148
Ni	106
Bi	14
V	92
Ag	16
Na	5,157
Zn	1,483
Zr	515
Co	42
K	3,391
Sr	226
Cd	42

TABLE 2

Volume of Liquid Sludge Hauled from Macon's Lower Poplar Street Plant*

Month		Year	
	1972	1973**	1974
January	189,880	0	0
February	0	0	0
March	141,639	6,963	12,845
April	33,560	0	4,404
May	12,390	6,890	28,442
June	0	3,975	4,771
July	15,980	0	19,226
August	63,858	0	2,110
September	4,240	0	15,047
October	0	0	35,416
November	45,844	0	0
December	19,091	0	15,414
Totals	526,482	19,828	137,675

*Volumes expressed in cubic feet

**During this year the digesters were undergoing major repairs; therefore, the sewage sludge was piped to drying beds.

ROCHELLE, ILLINOIS

The City of Rochelle, Illinois is a small community of approximately 9,000 population, located 75 miles west of Chicago, Illinois. The City's treatment facility is divided into two separate plants. The domestic wastes go to the activated sludge plant and the major industries' wastes go to the trickling filter plant. The activated sludge plant effluent subsequently is pumped to the later units of the trickling filter plant. All sludges are combined, thickened, vacuum filtered and applied to farmland.

Person Contacted

Mr. Paul Barry
Superintendent of Water and
  Waste Water Facilities
Rochelle Municipal Utilities
120 N. 7th Street
Rochelle, Illinois 61068
Telephone: (815) 562-2011

Site Description

Most of the City's vacuum filtered sludge is hauled to one farmer who is responsible for spreading the material on his fields and incorporating it into the soil. A limited amount is stockpiled at the plant for City residents to take. If a resident can use a full truck load, plant personnel will deliver it to his residence.

General Information

Mr. Paul Barry estimated the industrial input into the City's treatment facilities to be between 60 and 70 percent of the total flow. The population served by the plant is 9,000, with a population equivalent of 165,000. The design capacity is 4 MGD with an average daily flow of 3.2 MGD. The effluent from the trickling filter plant is discharged into the Kyte River.

The trickling filter plant receives wastes from a large slaughterhouse and also from a yarn dyeing company. The plant consists of paunch removal (for the packing house wastes only), preliminary units, primary settling units, three-stage trickling filtration, two-stage aerated tertiary lagoons, microscreening, and chlorination. The effluent from the activated sludge plant is directed to the tertiary lagoons. A portion of the waste sludge from the facilities is anaerobically digested. Both the undigested and digested sludges are then combined, thickened, and vacuum filtered. The plant produces 150 tons per week of sludge at 25 percent solids.

Sewage Sludge Composition

Table 1 presents data on the composition of the vacuum filter cake sludge.

Transport System

The City uses five trucks at the wastewater plant to haul the paunch manure, grit and screenings to the City sanitary landfill and the vacuum filtered sludge to the farm land. Four of the trucks have 8 yd^3 grain dump boxes and the newest has an 8 yd^3 heavy duty dump box. The grain boxes were purchased because of their lower cost. However, because of their light construction and the corrosive nature of the sludge, maintenance costs for the boxes are high.

Trucks are filled by backing them under a conveyor belt in the vacuum filter building. As one is being filled the other is being emptied. Three trucks are used in this operation while the other two haul grit and screenings. The haul distance to the farm is 13 miles round trip requiring 25 to 30 minutes. An average of 6 to 7 loads are hauled per day in a five day week.

Landspreading System

The farmer has a concrete paved feedlot which is not being utilized. The City trucks dump the sludge on the paved area for the farmer to spread. A farm manure spreader is used to spread the sludge on a daily basis. If the fields are dry, sludge is dumped directly on the field to reduce the haul distance for the farmer in spreading the material. The Illinois Environmental Protection Agency permit on the Rochelle Sludge Utilization Project, specifies that sludge cannot be stockpiled at a utilization site for longer than 2 months, that a maximum of 100 dry tons total accumulation can be applied to a site, and that sludge must be applied at or less than the acceptable nitrogen agronomic rate.

The farmer who is presently receiving the sludge applies about 25 wet tons per acre (6 dry tons/acre). In addition, based on soil tests, he applies 200 lb/acre of 0, 46, 0 commercial fertilizer. Through experience the farmer has learned that he must allow the sludge to dry on the field for about a day prior to incorporation in the soil with an offset disc or chisel. Otherwise, the sludge is too slippery for tractor operation.

Cost

The total cost to the City of Rochelle for sludge disposal on farm land is $89 per dry ton. This is a very complete figure which includes the depreciation, maintenance, and operating costs for the vacuum filter operation and truck hauling as well as all personnel cost. The dewatering operation accounts for about $75 per dry ton of this total cost. The major cost items which make dewatering so high are depreciation--$60,000, labor--$30,000 and chemicals--$25,000.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$ 3,510	
1969 Chev. Grain Truck, cost: $5,248		
1969 Chev. Grain Truck, cost: $5,248		
1972 Chev. Grain Truck, cost: $5,200		
1973 Chev. Grain Truck, cost: $6,000		
1974 I. H. Dump Truck, cost: $9,500		
Stationary Equipment Depreciation [2]	$29,140	
Vacuum Filter Building Depreciation [3]	$30,130	
Total Annual Capital Cost		$62,780

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
2 Laborers	$4.55	100	$18,930
1 Laborer	4.55	50	4,730
Laboratory	5.00	12.5	1,300
Maintenance	5.25	25	2,730
.Supervisor	10.00	20	4,160
			$31,850

Fringe Benefits at 25 percent	$ 7,960
Vehicle Operation and Maintenance	
Repairs	$ 3,150
Fuel and Oil	$ 1,000
Vacuum Filter Maintenance	
Chemicals	
Lime	$14,030
$Fe\,Cl_3$	$10,030
Acid	$ 1,080

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] Stationary equipment was depreciated over 10 years at 8 percent interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

[3] Buildings were depreciated over 20 years at 8 percent interest which amounts to a depreciation charge of $8.36 per $1,000 per month.

Parts and Repairs	$ 8,400	
Utilities		
Electricity @ $0.0239/kwh	$18,230	
Water	120	
TOTAL ANNUAL OPERATING COST		$ 95,850
TOTAL ANNUAL CAPITAL AND OPERATING COST		$158,630
10 PERCENT CONTINGENCY FACTOR [4]		$ 15,860
TOTAL ANNUAL COST		$174,490

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$174{,}490}{1950 \text{ dry tons}} = \$89/\text{dry ton}$$

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[4] A 10 percent contingency factor is added to cover such items as administrative overhead.

Table 1

Filter Cake Sludge Analysis

Ammonia Nitrogen (N)	.21% *
Organic Nitrogen (N)	2.41% *
Total Nitrogen (N)	2.62% *
Phosphorous (PO_4)	4.1% *
Phosphorous (P)	12.7 ppm*
Phosphorous (P_2O_5)	29.2 ppm*
Cadium	.2 ppm*
Zinc	135.2 ppm*
pH	12.1
Total solids	25.2%

*Reported on a dry weight basis

SALEM, OREGON

Salem, Oregon is a community of approximately 100,000 population, located 50 miles south of Portland, Oregon. The City's wastewater treatment facility consists of a secondary trickling filter with anaerobic digestion of the settleable solids, followed by lagoon drying and/or direct application of liquid sludge to nearby farmland.

Persons Contacted

Mr. Cliff Reed
Superintendent of Wastewater
Plant Operations
City Hall
555 Liberty Street, S.E.
Salem, Oregon 97301
Telephone: (503) 393-3806

Mr. Don Marske
CH_2M-Hill, Engineers
2929 North Mayfair Road
Milwaukee, Wisconsin 53222
Telephone: (414) 774-5530

Mr. Lyle Klampe
Field Representative - BIOGRO
City Hall
555 Liberty Street, S.E.
Salem, Oregon 97301
Telephone: (503) 393-3806

Site Description

The City hauls liquid sludge to several different site locations. Any farmer within a reasonable haul distance (i.e., five-mile radius) who desires to have sludge placed on his land may place a request with the City and, if conditions are right (e.g., weather, season of the year, site accessibility, runoff, groundwater table, etc.), the treatment plant will make one or two applications of sludge to his land.

General Information

The Superintendent of Wastewater Operations estimated the industrial input into the treatment facility to be approximately 6 percent of the total flow. However, during the summer months, the industrial input increases to approximately 50 percent of the total flow because of the seasonal industries (canneries) in the area. The population equivalent, based on a BOD of 0.17 lb/cap/day, is calculated to be 142,000. The overall treatment plant design capacity is rated at 14.7 MGD, with an average daily flow of 28 MGD. The effluent is discharged directly into the Willamette River. Because of the overload on the system, the City is currently in the midst of constructing a tertiary plant incorporating activated sludge, which is scheduled for completion by midsummer of 1976. With the expanded plant the City intends to dispose of sludge by liquid application, using modifications of its current system. This new system will incorporate the purchase of three new tank trailers which will be used to transport the liquid sludge to the field. The sludge will be pumped from the tankers to two 3-wheeled sludge applicator vehicles.

To encourage use of the increased sludge output from the expanded plant, the digested sludge produced is being promoted under the name of BIOGRO, an organic fertilizer and soil conditioner.

The combined quality of primary and secondary trickling filter sludge generated by the present system totals 50,000 gallons per day at 3.5 percent solids (i.e., 7.2 dry tons/day). The total sludge leaving the plant after digestion averages 6 million gallons per year at 5.5 percent solids (i.e., 1,376 dry tons/year or 0.087 lbs/cap/day). These figures compare closely to national averages with the same type of handling and processing.

Sewage Sludge Composition

No sludge analysis was available.

Transport System

Currently, the City hauls liquid sludge by a single 2,500 gallon tank truck, purchased in 1969 at a cost of $13,000. The decision to air dry or liquid haul is solely predicated upon the availability of a readily accessible field, weather conditions, season of the year, and the haul distance to the site. Generally, the City liquid hauls its sludge at 5.5 percent solids every week of the year.

The sewage sludge is stored in three anaerobic digesters (2.6 million gallons combined capacity) until spreading of the sludge occurs. During the 1975 year, it was reported that 2,000 loads were handled by liquid tank truck. Of the total amount of digested sludge, 80 percent is spread by liquid tank truck and 20 percent is piped to the lagoon drying beds. One driver is used full time during the periods when sludge is being liquid hauled. The average haul distance is approximately 10 miles, one way, with an average round trip driving time of 25 minutes. It takes approximately 10 minutes to load and 5 minutes to unload. The transport vehicle is unloaded by gravity flow with no spreading or distribution device.

The proposed "new" system will be implemented during the early part of 1976. This system will incorporate the use of the existing tank truck, plus three new 6,000 gallon tanktrailers, purchased at a total cost of $84,000. The four vehicles will be used solely for transporting liquid sludge to the disposal sites. Two new 3-wheel tank vehicles will be stationed at the disposal site, as they are strictly off-road vehicles and are more adapted to spreading and traversing land otherwise unaccessible to other types of transport vehicles. Upon arrival of the tanker, a 3-wheeler will be loaded and the liquid sludge applied at an even distribution rate.

Landspreading System

The liquid sludge is applied by gravity flow directly from the rear of the truck. The City has experimented with pumps and hoses but found it easier and more dependable to simply let the sludge drain by gravity. No problems of odors or flies were noted, even though the sludge is not always turned under immediately after application.

The City has been and is currently hauling most of its sludge to onion, grain, and pasture fields with the remaining sludge being stored in a holding pond at the wastewater facility. With expansion of the present plant, plans are to increase the efficiency of the landspreading operation to maintain costs at a minimum level.

Costs

Based on actual operating information provided by the City of Salem, it appears the City is currently disposing of its liquid sludge at a cost of $40 per ton of dry solids. Sludge handling and disposal cost will probably increase with full implementation of the new disposal system being proposed for the spring. This increase will be due basically to the increased cost of vehicle depreciation, operation and maintenance. A more detailed cost analysis of the present system is attached.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation [1]	$ 2,210	
1969, International, Cost: $13,000		
Standing Pipe Depreciation [2]	150	
Total Annual Capital Cost		$ 2,360

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$ 5.35	80	$ 8,900
Chemist	$ 5.80	5	600
Foreman	$ 5.80	100	12,060
Superintendent	$10.00	5	1,040
Overtime (10 hours every 2 weeks)			$ 1,390
			$23,990

Fringe Benefits at 23 percent	$ 5,520	
Vehicle Maintenance and Operation:		
Average at $420 per month	$ 5,040	
Contractual Costs	$ 5,000	
TOTAL ANNUAL OPERATING COST		$39,550
TOTAL ANNUAL CAPITAL AND OPERATING COST		$41,910
10 PERCENT CONTINGENCY FACTOR [3]		$ 4,190
TOTAL ANNUAL COST		$46,100

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$46,100}{1,146 \text{ dry tons}} = \$40 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8% interest which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

[3] A 10% contingency factor was included to cover such items as administrative overhead.

SALT LAKE CITY, UTAH

The City of Salt Lake City, Utah is a community of approximately 180,000 population. The City's wastewater treatment facility consists of a secondary standard rate trickling filter that incorporates prechlorination of the effluents. The settleables are pumped to anaerobic digesters. The digested sludge is either air dried in drying beds or centrifuged.

Person Contacted

Mr. Jack Peterson
Superintendent of Wastewater Operation
1850 N. Redwood Road
Salt Lake City, Utah 84116
Telephone: (801) 328-7611

Site Description

Centrifuged Sludge - The City hauls centrifuged sludge to either the Salt Lake City Airport or uses the sludge as fill material around the plant.

Air Dried Sludge - The City's air dried sludge is stockpiled for one year as required as a protective feature by state law prior to being made available to local citizens.

General Information

The treatment plant is a primary clarification system followed by a trickling filter, secondary clarification and discharge. The sludge goes through both primary and secondary anaerobic digesters, with a detention time of approximately three months at 3.0 to 3.5 percent solids.

The City Superintendent of Wastewater Treatment Facilities, estimated the industrial input into the City's treatment facilities to be less than 10 percent of the total flow. The population equivalent based on a BOD of 0.17 lbs/cap/day is 250,000. The overall treatment plant design capacity is rated at 45 MGD with an average daily flow of 41 MGD. The City is in the planning stages for a plant expansion.

The combined quantity of primary and secondary clarified sludge is approximately 43,500 lbs per day on a dry weight basis or 7,910 tons per year. This represents 0.24 lbs/cap/day which in comparison to the national average is above the norm. This can be partly explained by the type of industrial discharge.

Sewage Sludge Composition

No analysis was available.

Transport System

Centrifuged - The City currently hauls about 80 percent of its sludge at 21 percent solids when weather conditions permit and when the airport requests sludge. Dewatered sludge has been hauled to the airport for the past two years and used at the plant for the past ten years. Transporting this sludge is accomplished with a 1961 International 10-wheel - 13 ton dump truck purchased at a cost of $12,000.

It was reported that an average of two loads per day is hauled from the plant. The haul distance is approximately 5 miles one way with an average round trip driving time of 20 minutes. It takes 3 to 4 hours to generate a 5 ton load from the centrifuge which is then hauled to the airport or stored on a drying slab located at the plant.

Air Dried - The 1961 International 10-wheel is also utilized for hauling the air dried sludge since the haul distance is minimal. Once the vehicle is loaded it travels only several hundred feet before it off-loads.

The air drying beds collectively encompass an area of 300,270 ft^2 of actual available drying beds. Sludge is placed on the beds at 5 percent solids and 18 inches thick (i.e., 470 ton of dry solids). These beds are cleaned three times per year which involves two men working three 8-hour days, with the aid of a blade tractor and dump truck.

Landspreading System

The centrifuged dried sludge is dumped on the airport property by the treatment plant personnel. At this point the sludge becomes the responsibility of the airport to spread with their equipment. It is then used as fill material around the airport. In some instances (when weather conditions are unfavorable or when the airport is unable to take the centrifuged sludge) it is stored on a concrete slab located near the drying beds.

When sludge is utilized as fill material around the treatment plant, it is dumped in piles for spreading by a tractor. The sludge is later seeded. Even though the sludge is not covered with soil there were no apparent problems from odors or flies.

Costs

Based on information provided by the City, the air drying operation is the least costly of the two systems at $1 per dry ton. Because of the maintenance and repair cost involved, the centrifuge operation is more costly at $20 per dry ton of solids disposed. The above calculations do not include the cost for landspreading the sludge. The City's responsibility ends when the wastewater treatment plant deposits the sludge on the airport's property. A more detailed cost analysis follows.

COST FOR DISPOSAL OF AIR DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation	0	
Equipment Depreciation	0	
Total Annual Capital Cost		0

Annual Operating Cost

Personnel	Hourly Wage	% Time Worked	Cost
Operator	$4.98	[illegible]	$ 360
Laborer	3.75	4	$ 270
			$ 630

Fringe Benefits at 33 percent	$ 210	
Vehicle Maintenance and Operation		
Parts and Supplies	$ 60	
Fuel, Oil and Lube	$ 280	
Insurance	$ 10	
	$ 350	
TOTAL ANNUAL OPERATING COST		$1,140
TOTAL ANNUAL CAPITAL AND OPERATING COST		$1,140
10% CONTINGENCY FACTOR[1]		$ 110
TOTAL ANNUAL COST		$1,250

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$1,250}{1,410 \text{ dry tons}} = \$1 \text{ per dry ton}$$

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[1] A 10% contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF CENTRIFUGE DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation	0	
Equipment Depreciation[1]	$26,200	
2 - 1969 "Bird" centrifuges Cost: $180,000		
Total Annual Capital Cost		$26,200

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
Operator	$4.88	100	$10,150	
Operator	$4.88	100	$10,150	
Lab Technician	$5.00	25	$ 2,600	
Foreman	$5.80	5	$ 600	
			$23,500	
Fringe Benefits at 33 percent			$ 7,760	
Vehicle Maintenance and Operation				
Parts and Supplies			$ 2,270	
Fuel and Oil			$ 490	
Insurance			$ 40	
			$ 2,700	
Utilities and Other				
Electricity			$ 8,000	
Centrifuge Maintenance				
Maintenance, Parts and Labor			$26,000	
Contracted Balancing of Centrifuge Blades			$20,000	
			$46,000	
TOTAL ANNUAL OPERATING COST				$87,960
TOTAL ANNUAL CAPITAL AND OPERATING COST				$114,160

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[1] Stationary equipment was depreciated over 10 years at 8% interest which amounts to a depreciation charge of $12.13 per $1,000 per month.

10% CONTINGENCY FACTOR[2]	11,420
TOTAL ANNUAL COST	$125,580

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$125{,}580}{6{,}500 \text{ dry tons}} = \$20 \text{ per dry ton}$$

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[2] A 10 percent contingency factor was included to cover such items as administrative overhead.

SHEBOYGAN, WISCONSIN

The City of Sheboygan, Wisconsin is a community of approximately 50,000 population, located on the shore of Lake Michigan. The City's sewage treatment plant utilizes vacuum filtration followed by incineration of raw sludge and, in addition, utilizes anaerobic digestion followed by direct application of liquid sludge to farmland.

Person Contacted:

Mr. William Stubbe
Superintendent
Sewage Treatment Plant
3333 Lakeshore Drive
Sheboygan, Wisconsin 53081
Telephone: (414) 457-4713

Site Description

For the past four years the City has landspread its liquid sludge. In 1974, portions of 13 farms received sludge between the months of December and March. For this operation the City contracted with a septic tank cleaning firm to locate utilization sites, and haul and spread the liquid sludge. Sludge which is vacuum filtered is incinerated in the City's fluid bed sludge incinerator.

General Information

The sewage treatment plant was built in 1937 and expanded several times to include secondary trickling filters, vacuum filters, flash dryers and a fluid bed incinerator. The plant employs 15 full time personnel.

Industrial contribution to the plant is estimated to be 25 to 40 percent of the plant solids. The largest contributing industry is a leather tannery which discharges a heavy solids load. There are 21 plants which contribute over 10,000 g/d which include a refuse incinerator, a plastics plant and metal finishing plants.

During 1974, the treatment plant disposed of 10,618,000 gallons of sludge. Of this, 4,618,000 gallons at 3 to 4 percent solids were hauled for field spreading. The remaining 6,000,000 gallons were vacuum filtered to 21 to 24 percent solids and incinerated. The treatment plant design capacity is 22 MGD with an average daily flow of 10 MGD. The effluent is discharged into Lake Michigan. The population equivalent based on 0.17 lbs BOD/cap/day is approximately 120,000.

Sewage Sludge Composition

Table 1 presents data relative to the metals content of the liquid sludge.

Transport System

The City currently liquid hauls about 45 percent of its sludge. Sludge is only hauled when crops are off the fields and field conditions are such that the soil will not be compacted by the heavy trucks. As a result, sludge is normally hauled for about two months between December and March. The liquid sludge is hauled at 3 to 4 percent solids. This method of disposal has been used for the past four years. All hauling and spreading is handled by a contractor at a rate of $.0165/gallon.

The City's secondary digesters, which were built in 1937 and 1941, are used only for storage of sludge. The combined capacity of these digesters is 1,000,000 gallons.

All vacuum filtered sludge is incinerated.

Landspreading System

Little information on the landspreading system was available since the operation was contracted. The contractor uses an injection system to apply the sludge to the land. The application rate is .94 gallons/$ft.^2$ or 6 dry tons/acre. Each 3,000 gallon load covers an area 400 feet long by 8 feet wide. The principal crop grown on the treated soils is corn.

Cost

Based on operating information provided by the City, the cost for disposal of liquid sludge is $125 per dry ton. This is a high cost, but is a direct result of the high contract cost for transportation and disposal. The cost for the City to vacuum filter and dispose of residue, excluding incineration costs, is $380 per dry ton. This cost is very high because of depreciation costs of over $100,000, chemical costs of nearly $84,000 and personnel costs of over $60,000.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost				
Total Annual Capital Cost				$0
Annual Operating Cost				
Personnel	Hourly Rate	% Time Worked	Cost	
Superintendent	$7.54	1	$ 160	
			$ 160	
Fringe Benefits at 40 percent			$ 60	
Vehicle Maintenance and Operation				
Contract Hauling			$76,200	
TOTAL ANNUAL OPERATING COST				$76,420
TOTAL ANNUAL CAPITAL AND OPERATING COST				$76,420
10 PERCENT CONTINGENCY FACTOR[1]				$ 7,640
TOTAL ANNUAL COST				$84,060

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$84{,}060}{670 \text{ dry tons}} = \$125 \text{ per dry ton}$$

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[1] A 10 percent contingency factor is added to cover such items as administrative overhead.

COST FOR VACUUM FILTRATION AND RESIDUE DISPOSAL EXCLUDING INCINERATION

Annual Capital Cost

Vehicle Depreciation[1]	$ 1,530	
1968, Ford Dump Truck, Cost: $9,000		
Equipment Depreciation[2]	$60,670	
Building Depreciation[3]	$40,520	
Total Annual Capital Cost		$102,720

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Operator	$5.19	100	$10,210
Operator	4.91	100	10,210
Operator	4.91	100	10,210
Operator	4.91	75	7,660
Foreman	5.41	30	3,380
Superintendent	7.54	14	2,200
			$43,870

Fringe Benefits at 40 percent	$17,550	
Vehicle Operating and Maintenance		
Fuel and Oil	170	
Vacuum Filter Operation		
Repair	$11,260	
Chemicals	83,990	
Utilities		
Electricity	13,000	
TOTAL ANNUAL OPERATING COST		$169,840

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[1] Vehicles were depreciated over 8 years at 8 percent interest which amounts to a depreciation charge of $14.14 per $1000 per month.

[2] Equipment was depreciated over 10 years at 8 percent interest which amounts to a depreciation charge of $12.13 per $1000 per month.

[3] Buildings were depreciated over 20 years at 8 percent interest which amounts to a depreciation charge of $8.36 per $1000 per month.

TOTAL ANNUAL CAPITAL AND OPERATING COST	$272,550
10 PERCENT CONTINGINCY FACTOR[4]	27,260
TOTAL ANNUAL COST	$299,810

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Processed Annually}} = \frac{\$299,810}{790 \text{ dry tons}} = \$380 \text{ per dry ton}$$

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[4] A 10 percent contingency factor is added to cover such items as administrative overhead.

Table 1

Liquid Sludge Analysis*

Cr	5,000 ppm
Zn	1,400 ppm
Cd	13 ppm
Ni	130 ppm
Cu	130 ppm
Pb	260 ppm

* Chemical laboratory results are all on a dry weight basis.

SPRINGFIELD, OHIO

The City of Springfield, Ohio is a community of approximately 86,000 population, located between Dayton and Columbus, Ohio. The City's treatment facility consists of a trickling filter plant with secondary anaerobic digestion. The effluent receives post chlorination prior to discharge into the Mad River. Sludge is either liquid hauled to farm land, allowed to air dry in lagoons for use by private citizens, or used by the City as a top dressing on filled land.

Persons Contacted

Mr. R. J. Collins
Chief of Operations
Telephone: (513) 399-6841

Mr. Michael Justice, Superintendent
Water Pollution Control Department
965 Dayton Avenue
Springfield, Ohio 45501
Telephone: (513) 322-4949

Site Description

Liquid Sludge Disposal - The City hauls liquid sludge to one of several different site locations. In 1974, all liquid sludge was applied to about 75 acres. The soil is predominantly Miami silt loam. Farms for sludge application are selected on the basis of distance from the plant, access to fields, and distance from fields to dwellings.

Lagoon Dried Sludge - When weather, field conditions, or availability of truck drivers will not permit hauling of liquid sludge to farm land, it is pumped to one of several large lagoons for air drying. The lagoons are 5 to 6 feet deep and cover a total area of about 4 acres. However, the City prefers to only fill them to a depth of about two feet so they dry faster. After the sludge has dried, it is used as a top dressing on land that has been filled. A small amount is also stockpiled near a plant gate for private citizens to obtain for home gardening.

General Information

The City estimates the industrial input into the treatment facility to be approximately 33 percent of the total flow. The design capacity of the treatment plant is 25 MGD, with an average daily flow of 20 MGD. The BOD population equivalent is 87,203. This figure is only slightly over the population served figure of 86,000 because the major industrial input is as cooling water from assembly plants.

All treatment plant sludge receives secondary digestion prior to field application or being placed in lagoons. The total annual quantity of sludge is 5,373,000 gallons at 8 percent solids. Screenings amount to 240 cubic feet per year, which are incinerated at the plant. Grit amounts to an additional 240 cubic feet per year, which is dumped into the lagoons.

Sewage Sludge Composition

Sludge analysis, as provided by the City, is shown in Table 1.

Transport System

Liquid Sludge - The City currently liquid hauls about 30 percent of its sludge. The decision to liquid haul or lagoon is based on manpower available for hauling sludge, availability of fields for spreading, and weather conditions. In general, the City liquid hauls an average of one day per week with two 3,000 gallon tank trucks. An average of 10 loads per day are handled on haul days. In 1974, 520 dry tons of sludge were hauled. The majority of the sludge is hauled to two farms, each about four miles from the plant. The two tank trucks used in the operation were purchased in 1969 and 1973, at a cost of $11,269 and $14,402, respectively. The trucks are equipped with a cab controlled valve and gravity flow spread bar.

Lagooned Sludge - At times, when sludge needs to be removed from the plant but conditions are not favorable for liquid hauling, sludge is pumped into one of three large lagoons. The lagoons are sloped to the far end from the inlet, with an average depth of five to six feet. Normal procedure is to fill the lagoons to a depth of about two feet to allow for faster drying. In 1974, a total of 3,805,000 gallons of sludge at 8.3 percent solids were added to the lagoons and 4,880 cubic yards at 60 percent solids were removed. A tracked, 1 1/2 cubic yard bucket loader, purchased in 1969 for $11,496, is used exclusively to load sludge from the lagoons into dump trucks. Two 10 cubic yard dump trucks are used 95 percent of the time for transporting lagooned sludge. They were purchased in 1969 and 1974 at a cost of $10,800 and $15,843, respectively. Most of this sludge is hauled to City land where it is used as a top dressing.

Landspreading System

Liquid Sludge - The liquid sludge is applied by gravity flow directly from the rear of the truck. A spreader pipe is used to give an even application over about an eight foot width. In 1974, 1,568,000 gallons of sludge were applied to 75 acres for an average application rate of 7 dry tons per acre. Most of the land which receives sludge is tilled and planted with corn or wheat crops. No sludge is spread within

500 feet of a dwelling. To date, there have been no complaints about the operation.

Costs

In 1974, the City disposed of 520 dry tons of liquid sludge on farm land at a cost of $22 per dry ton. In comparison, the City lagoon dried and disposed of 2,180 dry tons of sludge at a cost of $9 per dry ton in 1974. A breakdown of the costs included in this analysis is attached.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]			$4,360	
1969 International, cost: $11,300				
1973 International, cost: $14,400				
Total Annual Capital Cost				$4,360

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost	
Driver	$5.00	19	$2,000	
Chemist	10.00	4	800	
Superintendent			400	
			$3,200	
Fringe Benefits at 40 percent			$1,280	
Vehicle Maintenance and Operation				
Fuel and Oil			$ 450	
Repairs			1,000	
Insurance			80	
Utilities				
Electricity for Pumping			10	
Pumping Facility Maintenance			10	
TOTAL ANNUAL OPERATING COST				$6,030
TOTAL ANNUAL CAPITAL AND OPERATING COST				$10,390
10 PERCENT CONTINGENCY FACTOR[2]				$1,040
TOTAL ANNUAL COST				$11,430

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$11,430}{520 \text{ dry tons}} = \$22 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] A 10 percent contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF LAGOON DRIED SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	$6,460	
1969 1 1/2 yd^3 bucket loader, cost: $11,496		
1969 Dump Truck, cost: $10,800		
1974 Dump Truck, cost: $15,843		
Stationary Equipment Depreciation	$0	
Building Depreciation	$0	
Total Annual Capital Cost		$6,460

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Driver	$5.00	34	$4,050
Chemist	10.00	9	1,820
Superintendent			350
			$6,220

Fringe Benefits at 40 percent	$2,490	
Vehicle Maintenance and Operation		
Fuel and Oil	$470	
Repairs	$2,000	
Insurance	150	
TOTAL ANNUAL OPERATING COST		$11,330
TOTAL ANNUAL CAPITAL AND OPERATING COST		$17,790
10 PERCENT CONTINGENCY FACTOR[2]		$1,780
TOTAL ANNUAL COST		$19,570

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$19,570}{2,180 \text{ dry tons}} = \$9 \text{ per dry ton}$$

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

[2] A 10 percent contingency factor is added to cover such items as administrative overhead.

TABLE 1

Springfield, Ohio, Sludge Analysis (ppm)
(dry weight basis)

Date	Cd	Cr	Cu	Ni	Pb	Zn
2/73	--	277	105	34	105	108
5/73	--	400	102	42	115	1,492
3/74	5	62	32	45	31	106
1/75	88	877	17	75	154	584
3/75	17	477	15	69	--	226
8/75	--	1,712	170	62	--	--
12/75	52	1,530	170	152	206	830

TOLEDO, OHIO

Toledo, Ohio is located in Northwestern Ohio approximately 50 miles south of Detroit, Michigan. The activated wastewater treatment plant serves a population of approximately 500,000. Design capacity of the plant is 100 MGD and average daily flow is 92 MGD. Approximately [illegible] percent of the collection system is combined sanitary and storm sewers, the remainder is sanitary only. Dewatered sludge is routinely hauled to farmland and some experiments with liquid sludge have been conducted.

Persons Contacted

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Mr. Gerald Baumgartner
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Site Description

The largest portion of the sludge is handled under contract with Soil Enrichment Materials Corporation (SEMCO). This firm has contracted for 867 acres of farmland. To date only 415 acres have received sludge. The land is actively farmed and the principal crops grown are corn, soybeans, wheat and oats.

The City also spreads dewatered sludge on its own land. Sludge is applied twice annually to land adjacent to the House of Correction. Of the 155 acres available, 30 acres have received 2 applications while another 30 acres have received one application. Corn, hay, and soybeans are grown on this land.

There have also been experimental landspreading trials for liquid sludge. These experiments have been conducted by individuals. The City personnel felt that high trucking costs would make the landspreading of liquid sludge economically unattractive, but mechanically, a more manageable system. Barging or rail haul are under consideration. Experiments are also contemplated to assess the economics and feasibility of composting.

General Information

The original facility at this location was a pump station constructed in 1916. Primary treatment was built during the late 1920's with anaerobic digesters. Secondary treatment was added in 1959. In 1968 vacuum filters were added and landfilling of the sludge was begun. Prior to 1968 sludge lagoons were used. In 1973 the present landspreading programs were initiated. Additional capacity was added to the secondary treatment system in 1974.

A solids content ranging from 6 percent to 9 percent is obtained from the two-stage anaerobic digesters. The vacuum filters increase the solids content to about 20 percent. Between 200 and 250 tons per day of filter cake are produced six days per week.

Sewage Sludge Composition

Characterization of the sludge cake is attached.

Transport System

The sludge is dewatered to 20 percent solids on coil vacuum filters. City personnel use a single axle tractor to position the 30 cubic yard trailers, under a conveyor belt for loading. (The trailers are owned by a contractor). After the trailers are loaded they are positioned in a parking area for the trucking firm which delivers them to the SEMCO site or the City's site at the House of Correction's Farm. The haul distance to the SEMCO site is 45.2 miles one-way requiring a round trip driving time of 2.5 hours. The distance to the House of Correction's Farm is 34 miles each way. At the landspreading sites the trailors are unloaded at a central stockpiling location.

Landspreading System

SEMCO has a contract for 867 acres in Wood County which can be used for sludge application at no cost to the farmer. A compacted crushed limestone pad has been prepared at the site for stockpiling the sludge while it awaits application to the fields. When weather and cropping conditions will permit, sludge is loaded with a 4-yard loader into a farm manure spreader or a Field Gymmy for application to the land. The Field Gymmy has an 8-yard hopper box, high flotation tires and a rear spinner assembly for spreading. This piece of equipment is preferred over the manure spreader because it compacts the field less, distributes the load more evenly and is able to operate in wetter fields than the tractor-drawn spreader. The normal application rate is 10 dry tons per acre per year but varies from 5 to 30 dry tons per acre.

The landspreading at the House of Correction is done in a similar fashion. The City also owns a Field Gymmy and keeps a front end loader at the site for loading. Because of cropping practices used on this farm, landspreading is done only in the spring and fall. The application rate is between 10 and 13 dry tons per acre per year.

Costs

The annual sludge treatment and handling costs are estimated to be between 40 and 50 percent of plant operating costs. The contract with SEMCO separates the hauling and spreading costs. The firm iszpaid $2.92 per wet ton for hauling and $3.24 per wet ton for spreading. Based on operating information provided by the City of Toledo, the City is currently disposing of its vacuum filtered sludge at a cost of $117 per dry ton. The cost of dewatering accounts for about $77 per dry ton. The major cost factors for dewatering are dept retirement of about $500,000 and labor, chemical and power costs for operating the vacuum filters of about $730,000. A breakdown of costs that were available from the City is attached.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost		
Debt Service on Vacuum Filters and City Owned Trucks	$500,000	
Total Annual Capital Cost		$ 500,000
Annual Operating Cost		
Labor, Chemicals and Power to Operate Vacuum Filters	$730,000	
Sludge Hauling (contract @ $2.92/wet ton)	237,000	
Sludge Spreading (contract @ $3.24/wet ton)	263,000	
TOTAL ANNUAL OPERATING COST		$1,230,000
TOTAL ANNUAL CAPITAL AND OPERATING COST		$1,730,000
10% CONTINGENCY FACTOR [1]		$ 173,000
TOTAL ANNUAL COST		$1,903,000

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$1{,}903{,}000}{16{,}250 \text{ dry tons}} = \$117/\text{dry ton}$$

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[1] A 10% contingency factor is added to cover such items as administrative overhead.

SLUDGE CAKE CHARACTERIZATION

TOLEDO WATER RECLAMATION PLANT

PARAMETER*	RANGE	AVERAGE	AVERAGE POUNDS PER DRY TON
% Solids	14.5 - 27	20	
% Volatile Solids	38 - 50	44	
% Fixed Solids	62 - 50	56	
% T O C	16 - 18	17.4	
pH	10 - 13	12	
Density	1.05 - 1.09	1.067	
PCB	0.5 - 5	2	
HEAVY METALS			
Aluminum	2,200 - 53,500	16,000	32
Arsenic	3 - 17	12	0.024
Beryllium	0.5 - 1	0.7	0.0014
Boron	5.6 - 16.1	7.5	0.015
Cadmium	23 - 41	26	0.052
Calcium	60,000 - 135,000	102,000	204
Chromium	47 - 1,120	676	1.35
Copper	420 - 1,570	650	1.3
Iron	22,000 - 101,000	71,000	142
Lead	340 - 720	526	1.05
Magnesium	6,700 - 22,000	10,300	20.6
Manganese	870 - 35,000	10,400	20.8
Mercury	0.01 - 2.2	1.1	0.002
Nickel	41 - 696	450	0.81
Selenium	1 - 67	19	0.038
Sodium	83 - 910	690	1.38
Zinc	1,850 - 4,050	2,740	5.48
NUTRIENTS			
% Nitrogen-Total	1.72 - 2.42	2.08	41.6
% Nitrogen-Organic	1.23 - 2.38	1.48	29.6
% Nitrogen-NH_3	0.002 - 0.64	0.222	4.4
% Nitrogen NO_2-NO_3	6 - 60	30	0.06
% Phosphorus-Total	2.13 - 2.95	2.5	50
Phosphorus-Water Soluble	40 - 240	120	0.24
% Potassium	0.027 - 0.35	0.17	3.4

* ppm unless otherwise indicated

YORK, PENNSYLVANIA

York, Pennsylvania is located in the southeastern part of the state, about 45 miles straight north of Baltimore, Maryland. The City's wastewater treatment plant utilizes activated waste treatment and serves a population of 115,000. Sludge from the plant is transported in both liquid and dewatered (vacuum filtered) state to farm land. Design capacity of the plant is 18 MGD. The average daily flow is 16 MGD.

Person Contacted

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Superintendent of Wastewater Treatment
Department of Public Works
York, Pennsylvania
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Site Description

The City is presently utilizing 40 farms having a collective acreage of over 4,490 acres. Most of the land utilized is actively farmed with corn being the principal crop. Two farmers leave alternating strips of their fields fallow for sludge disposal in bad weather. These strips are planted in grasses.

General Information

The wastewater treatment plant was constructed in 1916 and upgraded in 1954 to activated sludge. Design capacity of the plant is 18 MGD with an average daily flow of 16 MGD. Sludge in the plant is anaerobically digested and then stored in an elutrification tank for vacuum filtration. Liquid sludge for the tank trucks is drawn directly from the secondary digesters.

The anaerobically digested sludge is about 4.5 percent solids. A portion of the sludge is dried by vacuum filtration which results in a sludge having a 16 percent solids content. The total dry weight of sludge leaving the plant in 1975 was 2,330 tons. Of this 1,360 dry tons were as a liquid and 970 dry tons as vacuum filtered sludge. There are 23 major industries which contribute an estimated 50 percent of the flow.

The City is presently initiating action to proceed with the findings of an engineering study conducted several years ago which recommended that a sludge incinerator in the plant be upgraded to meet present emission standards so it can once again handle all the generated sludge.

Sewage Sludge Composition

The analysis of York's sludge, as shown in Table 1, indicates that the sludge is high in Cd.

Transport System

Sludge is normally removed from the plant five days a week regardless of weather conditions. The vacuum dried sludge is hauled in two five cubic yard dump trucks to two farms, one three miles from the plant and the other six miles.

Liquid sludge is hauled to one of 40 farms five days a week, weather permitting. The City has five 2,500 gallon tank trucks. Of these, one is standby and the other four average five loads each per day. The sites are an average of about 20 miles round trip distance from the plant with a driving time of about one hour.

The apparatus for loading the trucks consists of a belt conveyor from the vacuum filters to the dump trucks and a gravity flow stand pipe for the liquid sludge.

Landspreading Operation

The dried sludge is dumped in piles in the fields for later spreading with a dozer by the farmer. Normally sludge has to be stockpiled on a portion of the treatment plant property for about two months of the year when it is impossible to get into the fields. The sludge is then later loaded on other city trucks and hauled to the farms. Only two farms receive dried sludge.

The liquid sludge trucks are equipped with pumps which spray the sludge over a 10 foot strip, starting about 5 feet from the truck. Application is very even and unloading time is about five minutes. During wet weather, sludge is applied to grass land or along graveled lanes. Edges of fields along lanes often receive as many as 30 to 40 applications per year. Other fields receive one to five applications per year, depending upon the crop. The heaviest single application applied is four loads per acre (i.e., 2 dry tons). All farmers except the two who will take the dried sludge are charged $2 per tank truck load for the sludge. Income from this in 1974 was $1,384. The only monitoring of sludge utilization sites is being done by the U.S. Department of Agriculture's Agricultural Research Service.

Costs

The treatment plant was completed in 1954. Since buildings were depreciated over 20 years and stationary equipment over 10 years, there are no depreciation costs for these items. Based on actual operating information provided by the City, detailed costs were determined for the annual capital and operating expenses for liquid haul and vacuum filtration and hauling of sludge. The total cost per dry ton of liquid sludge hauled was $73 and for vacuum filtration $165. With the vacuum filtered sludge, the cost of dewatering accounts for about $140 per dry ton. The major reasons for high dewatering costs are that repairs on the older vacuum filters cost about $60,000 and labor to operate them cost about $53,000. A detailed breakdown is attached.

COST FOR DISPOSAL OF LIQUID SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	$8280	
1964 RIO Tank Truck		
1967 RIO Tank Truck		
1968 Diamond T Tank Truck, cost: $16,148		
1970 International Tank Truck, cost: $16,173		
1970 International Tank Truck, cost: $16,528		
Stationary Equipment Depreciation	$0	
Building Depreciation	$0	
Total Annual Capital Cost		$8,280

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
4 Truck Drivers	$4.25	100	$35,360
Auto Mechanic	4.54	54	5,060
Laboratory Assistant	5.77	5	600
Chief Operator	6.00	23	2,810
Supervisor	7.50	5	720
			$44,550

Fringe Benefits at 40 percent	$17,820	
Vehicle Maintenance and Operation		
Repairs	$ 9,670	
Fuel and Oil	8,010	
Insurance	2,890	
TOTAL ANNUAL OPERATING COST		$82,940
TOTAL ANNUAL CAPITAL AND OPERATING COST		$91,220

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

10 PERCENT CONTINGENCY FACTOR[2]	$ 9,120
INCOME FROM SALE OF LIQUID SLUDGE	$ 1,380
TOTAL ANNUAL COST	$98,960

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$98{,}960}{1{,}360 \text{ dry tons}} = \$73 \text{ per dry ton}$$

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[2] A 10 percent contingency factor is added to cover such items as administrative overhead.

COST FOR DISPOSAL OF VACUUM FILTERED SLUDGE

Annual Capital Cost

Vehicle Depreciation[1]	$3,150	
1970 Chevrolet Dump Truck, cost: $6,808		
1974 Diamond T Dump Truck, cost: $11,708		
Plant Equipment Depreciation	$0	
Total Annual Capital Cost		$3,150

Annual Operating Cost

Personnel	Hourly Rate	% Time Worked	Cost
Truck Driver	$4.25	100	$8,840
Auto Mechanic	4.54	19	1.770
2 Vacuum Filter Operators	503	100	20,920
Vacuum Filter Laborer	3.86	100	8,030
Vacuum Filter Laborer	3.73	100	7,760
Laboratory Assistant	5.77	5	600
Chief Operator	6.00	2.5	310
Supervisor	7.50	5	720
			$48,950

Fringe Benefits at 40 percent	$19,580
Vehicle Maintenance and Operation	
Repairs	$ 2,100
Fuel and Oil	430
Insurance	1,130
Vacuum Filter Maintenance	
Chemicals	$ 9,590
Parts and Repair	60,000
Utilities	$1,000

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[1] Vehicles were depreciated over 8 years at 8 percent interest, which amounts to a depreciation charge of $14.14 per $1,000 per month.

TOTAL ANNUAL OPERATING COST	$142,780
TOTAL ANNUAL CAPITAL AND OPERATING COST	$145,930
10 PERCENT CONTINGENCY FACTOR[2]	$ 14,590
TOTAL ANNUAL COST	$160,520

$$\frac{\text{Total Annual Cost}}{\text{Total Sludge Hauled Annually}} = \frac{\$160{,}520}{970 \text{ dry tons}} = \$165 \text{ per dry ton}$$

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[2] A 10 percent contingency factor is added to cover such items as administrative overhead.

TABLE 1

Sludge Sample from York, Pennsylvania

Dry Weight	4.4 percent
Ash	39.0 percent
Zn	3,260 mg/kg
Cu	770 mg/kg
Ni	200 mg/kg
Cd	65.1 mg/kg
Pb	960 mg/kg
Cd/Zn	2.0 percent
Zn (Eq)	5,400

Values reported as mg/kg are on a dry weight basis.

μσ1542
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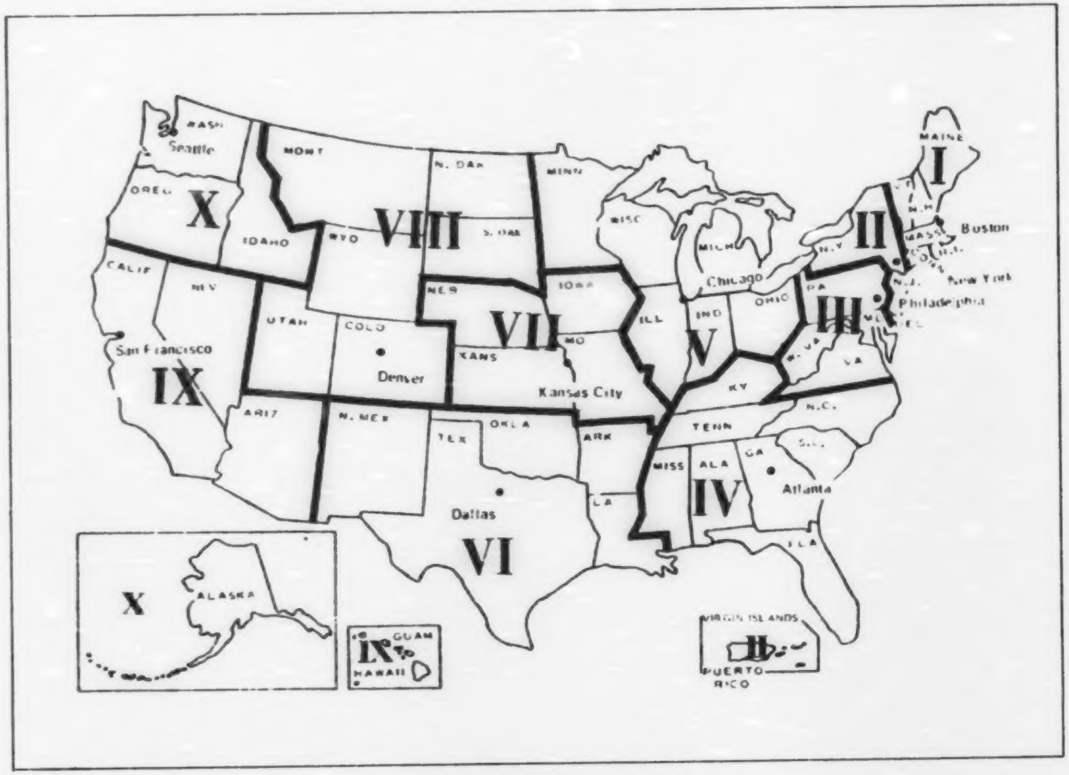
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